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Preface.

VALEDICTORY.

DEAR FRIENDS,—

IT is with the deepest regret that I write the word which appears above. The present part completes the SIXTEENTH Annual Volume of the INTERNATIONAL JOURNAL OF MICROSCOPY AND NATURAL SCIENCE, and during the whole of those sixteen years I can honestly say that I have spared no labour to make it worthy of the name it bears. That I have succeeded in winning the approbation of a great number of subscribers I have many letters to prove. But for several years the result of the sales has not been sufficient to pay the printer's bills, and this year I feel myself so far in arrears that I dare go on no further.

I cannot close without tendering my best thanks to those subscribers who have helped me by their kind support, and especially those—and they are many—who have been subscribers from the first; also to those who have contributed valuable papers, and have promised others for next year, which I shall be obliged to "decline with thanks."

My thanks are also due to my publishers, Messrs. Bailliere, Tindall, and Cox, from whom I have always received the greatest courtesy and kindness.

I trust the discontinuance of the Journal will not in any way interfere with the steady and efficient working of the Postal Microscopical Society, which will hold its Annual Meeting at the Holborn Restaurant on Thursday evening, the 21st inst. All friends of the Society and of the Journal will be welcome to attend. For particulars and Tickets apply to me.

Yours very faithfully,

ALFRED ALLEN,

Editor.

1 Cambridge Place, Bath;

October, 1897.

THE INTERNATIONAL
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"*Knowledge is not given us to keep, but to impart; its worth is lost in concealment.*"

[The Editor does not hold himself responsible for the views of the authors of the papers published.]

Presidential Address: "What is a Spider?"

By Dr. J. S. Walker. Plate I.

THE scientific characteristics of an insect is a creature whose body is divided into three parts, has two antennæ, six legs, and passes through four stages of metamorphosis; but a spider is not an insect. The spider belongs to the *Araneidea*, an order of the *Arachnida* which, in common with insects, is a sub-class of the Arthropoda. The body of a spider is made up of two parts: the cephalothorax and the abdomen.

There are nine orders of Arachnida :—

1.—Scorpions *(Scorpiodea)*, in which the respiration is by air-chambers, and there is a post-abdomen ending in a claw.

2.—*Cheliferidea*, in which the respiration is by tracheæ; the abdomen is not distinctly separated, and the maxillary palpi have two claws.

3.—*Acaridea*, with unsegmented abdomen, which is united to the cephalothorax.

4.—Spiders (*Araneidea*), in which the unsegmented abdomen is distinct from the cephalothorax.

5.—Harvest Spiders *(Phalangidea)*, in which the respiration is by tracheæ; the abdomen is not distinctly separated from the cephalothorax, and the maxillary palpi have only one claw.

6.—*Phrynidea*, in which respiration is by air-chambers, and there is no post-abdomen.

7.—*Solpugidea*, in which the respiration is by trachea, and the abdomen is separated from the cephalothorax.

8.—Water bears *(Arctisca)*, which have a vermiform body, with four pairs of rudimentary limbs.

9.—*Pentastomidea*, which have a vermiform body, the embryo only with two pairs of rudimentary limbs.

SPIDERS (*Araneidea)*, an order of the class *Arachnida.*

The body of a spider is divided into an unsegmented cephalothorax and a swollen abdomen, also unsegmented and attached to the former by a narrow stalk. The cephalothorax is covered above by a plate or carapace, more or less horny, while the abdomen is generally soft. The whole body is covered with hairs, bristles, or tubercles.

Attached to the cephalothorax there are four pairs of seven-jointed walking limbs, which are usually long and slender, ending in two claws, and to which one or more claws are sometimes added. Above these are another pair of appendages, the pedipalpi, answering to the maxillæ of insects; their bases act as jaws; and their palpi are five-jointed, and in the female resemble simple legs, but in the male their terminal joint is peculiarly modified as a copulatory organ.

Above the mouth are the first pair of appendages, the falces or cheliceræ which consist of two joints and a powerful basal joint grooved on its inner surface, also a claw-shaped terminal joint or fang, at the point of which the duct of a poison-gland opens. These fangs, whose office is to catch and kill the prey, are, when not in use, folded back into the groove of the basal joint.

The basal joint has generally a row of teeth on one or both edges of the groove, and assists in eating, moving usually from side to side. On the first margin of the cephalothorax are usually eight, sometimes six or less simple eyes. The abdomen is always larger or more swollen in the female. On its ventral surface in

front are one or two pairs of respiratory apertures, and between them the unpaired genital aperture.

The anus is placed at the extremity of the abdomen on the ventral surface, and is surrounded by two or three pairs of spinnerets.

The mouth opens into a short œsophagus with horny walls, which terminate in a dilated radiating, suctorial stomach, from which are given off four or five pairs of cæca running into the legs. The intestine is narrow, and opens into a short dilated rectum, which receives a pair of much branched urinary or Malpighian canals. Salivary glands open into the anterior portion of the œsophagus. The liver is very large and much branched, opening into the intestines.

The vascular system is well developed. The blood is colourless. The heart is a chambered dorsal vessel, situated in the abdomen, from which an aorta runs forward into the cephalothorax giving off lateral arteries to the legs, jaws, brain, and eyes. In the fore part of the cephalothorax, these arteries reunite, surrounding the brain, and forming the abdominal aorta, which runs backwards into the abdomen. The blood, after making its way through the tissues and bathing the lung-sacs, re-enters the heart by three pairs of lateral valves.

Respiration is effected partly by lung-sacs, composed of a number of delicate lamellæ and partly by tracheæ or air-tubes. There are one or two pairs of lung-sacs situated in the anterior portion of the abdomen, and opening by slit-like stigmata. The tracheæ open by a pair of stigmata, further down, sometimes quite at the extremity of the abdomen.

The nervous system is concentrated in a cerebral ganglion, or brain, and a large ganglionic mass, situated in the thorax and supplying nerves to the legs and abdomen.

Spiders possess an apparatus for the production of a viscid fluid, which has the property of hardening into silk on exposure to the air. This apparatus consists of numerous glands pouring their secretions through fine pores on to the surface of the spinnerets, which are from two to four pairs of conical papillæ placed behind the anus. The apex of these spinnerets is surrounded by stiff bristles and hairs, and is dotted with numerous horny tubes,

through the pores at the end of which the secretion escapes in threads of extreme fineness, thousands of which are united to form a single strong thread, as used in the web.

The spiders are all oviparous, and a single impregnation is sufficient for several successive generations. The eggs are numerous, and are usually enclosed by the female in a silken bag which she carries about with her, or hides in her nest, or in some cases attaches to stones, plants, etc. The young, when hatched, resemble their parents in form, but they cannot spin nor capture prey till after the first moult.

Spiders are found in every habitable portion of the globe, but are larger and more abundant in warm climates. The males and females live separately, and the latter are more frequently seen and are considerably the larger. All are carnivorous, devouring living prey, chiefly insects and other arthropods, sucking the juices and sometimes swallowing the fragments. The females are generally ready to attack and feed on the males, even in the reproductive season, and both sexes are fond of fighting, the vanquished being devoured. They can support long fasts and remain torpid during the winter. In making their webs, they accommodate themselves remarkably to circumstances, displaying great perseverance, ingenuity, and intelligence. They carefully guard their eggs and are affectionate to their young, which in some cases devour their mother.

The webs sometimes form nets for the capture of prey, and sometimes they are used partially or wholly as dwelling-places. They descend by their silken threads head downwards, but climb upon them head upwards, rolling the threads into a bundle during the ascent. The thread cannot be used for the same purpose a second time. When they wish to go from tree to tree, some let go a thread in the direction of the wind, and when it has reached the object they strengthen it, and pass over occasionally in this way, travelling long distances without descending to the ground. Young spiders of several families frequently float in the air, supported by a few threads of silk.

They are capable of some domestication. Pelisson, a prisoner in the Bastille, had a pet spider, which came regularly at the sound of a musical instrument to get its meal of flies. In former

days both spiders and their webs were thought to be efficacious in intermittent fevers, etc. The web is still used as a styptic. Attempts have been made to render the silk surrounding the eggs available for manufacturing purposes, but with little success, as the silk is inferior in strength and lustre to that of the silkworm, and cannot be wound. The poison of some of the foreign species is very virulent and is dangerous to human beings. Spiders are eaten by some tribes in various parts of the world, and are preyed upon largely by birds and reptiles.

The order *Areneidea* is divided into two sub-orders: *Tetrapneumones*, with two pairs of lung-discs and two pairs of spinnerets; and *Dipneumones*, with one pair of lung-discs and usually six or eight spinnerets. The first sub-order contains only the family *Mygalidæ*, chiefly from the warmer parts of the world.

There are twelve varieties of spiders found in England:—

The British trap-door spider		-	*Atypus Sulzeri.*
The Bush	" "	-	*Anglena Nava.*
The Bramble	" "	-	*Nereine rubella.*
The Crab	" "	-	*Thomisus eristatus.*
The Garden	" "	-	*Epeira diadema.*
"	" "	-	*Dolimedes mirabilis.*
The Ground	" "	-	*Lycosa Agretyca.*
The Field	" "	-	*Lyniphia minuta.*
The Long-legged Grass	"	-	*Tetragnatha extensa.*
The Cellar	" "	-	*Tegenaria domestica.*
The House	" "	-	*Aranea labyrinthica.*
The Harvest	" "	-	*Phalangium cornutum.*

The gigantic tropical species of *Mygale* live in trees and under stones, etc., in a tubular silken dwelling, from which they issue forth at night in pursuit of prey; one species from South America (*Mygale avicularia*, Fig. 1) kills and devours small birds. The trap-door spider (*Cteniza*, etc.) also belong to this family, living in burrows in the ground, which are lined with silk and closed with an accurately fitting lid; the only British species of the family (*Atypus Sulzeri*) lives also in burrows, but does not construct a trap-door.

The family *Salticidæ*, or jumping spider, are small or of moderate size, and abundant all over the world. They prepare

no snare for the capture of their prey, but crawl up to it stealthily, and capture it by a sudden spring.

Salticus scenicus is common everywhere in Britain on walls, trees, palings, etc.; another British species, *Salticus formicarius* closely resembles an ant. The *Lycosidæ* (see Fig. 2), or wolf spiders, are also wandering spiders, catching their prey by running it down. Some of the American species are very large, and all are remarkable for ferocity; some, as our common *Lycosa piratica*, run on the surface of water and catch insects. The Tarantula (*Lycosa tarantula*), of Southern Europe, has acquired an evil reputation, its bite being supposed to induce delirium and madness. The *Thomisidæ*, or crab spiders, are so called from their short body and long crab-like fore-legs, as well as from their habit of running sideways; they are small spiders, numerous and widely distributed, concealing themselves usually in herbage and flowers (see Figs. 3 and 4).

The British species are numerous. The *Tegenariidæ*, or *Tubitelæ*, form a very large family, the members of which weave a large web with a tubular portion, which serves as a hiding-place.

The common house spider (*Tegenaria domestica*) belongs to this group, and also the water spider (*Argyroneta aquatica*), which constructs its nest beneath the surface of the water. The family *Theridiidæ* is most numerous in the temperate parts of the Old World. The species construct irregular webs in which to catch their prey. The bite of one of the species, the *Malmignatte (Latrodectus Malmignattus)*, common in the south of Europe, especially in Corsica, produces serious and even fatal effects in human beings.

The *Epëiridæ*, or geometric spiders, construct beautiful, regular circular webs, with threads radiating from the centre and connected by cross-threads. The typical genus *Epëira* contains the common garden spider (*Epëira diadema*) (see Fig. 5). In tropical America are several curious spiders of allied genera, which have the abdomen more or less horny, and produced into spines or long processes.

The harvest spiders, or harvest men, belong to a distinct order, *Phalangidæ*.

In conclusion, it may be stated, this is solely natural history,

quite true; but a good microscopist likes to know what to look for, and what is most interesting, Some have made a study of the web alone, and it is astonishing what a difference there is in each family. Then, again, there has been some discussion how the young of a spider is sustained. Mr. Samborn states that they are suckled, and has seen milk oozing out of the spinnerets. Then there are the spinnerets, the feet, which have two claws, and a serrated appendage, so as to enable them to slide down on the web. The head is exceedingly interesting; the eyes are simple ocelli and are a fascination to the embryologist; also observe the mandibles, a basal thick one, and a terminal one, curved and sharply pointed, which is connected with the poison-gland. Some authors consider these modified antennæ. Then comes the maxillary palpi, which terminates in the female in a small hook. The tracheæ and stigmata of the latter, and also the ovipositor. There are four spinnerets on each side, thus showing that their habits and structure offer a very wide scope for industrious work to the microscopist.

I ought not to conclude my address without speaking of the microscopical technique, which requires some practice and attention. Even to mount the feet of a spider, one difficulty is to get them free from dirt and hair.

First, as to the bleaching. This may be done in several ways, either with hydrochloric acid and chlorate of potash, or by a simple solution of potash (*Liquor Potassæ* of the British Pharmacopœia), or a solution of chlorate of soda or lime; but any of these chitinous arachnidæ or acari must be watched, as if left too long in solution they break up entirely. It is better to take the specimen out of the solution before it gets quite clear than leave it too long, as whilst it is being washed it continues bleaching; it should now be washed in distilled water to free it from the drug, then in a little spirit, then in some turpentine, and again in xylol or spirit, and lastly in clove oil. For mounting I prefer the balsam dissolved in turpentine, but great care must be taken to touch the specimen with a small piece of filter paper whilst on the section-lifter, so as to absorb and free it entirely from the clove oil, or it will be cloudy when examined under the microscope.

EXPLANATION OF PLATE I.

Fig. 1.—*Mygale avicularia*, natural size.
,, 2.—*Lycosa itquilina*, the Wolf Spider.
,, 3.—*Thomasis abbreviatus*, slightly magnified.
,, 4.—*Thomasis lamio.*
,, 5.—*Epeira diadema*, Common Garden Spider.
,, 6.—*Tegenaria guyonii*, somewhat enlarged.
,, 7.—*Dolomedes fimbriatus*, slightly magnified.

On the Nature of Supernumerary Appendages in Insects.

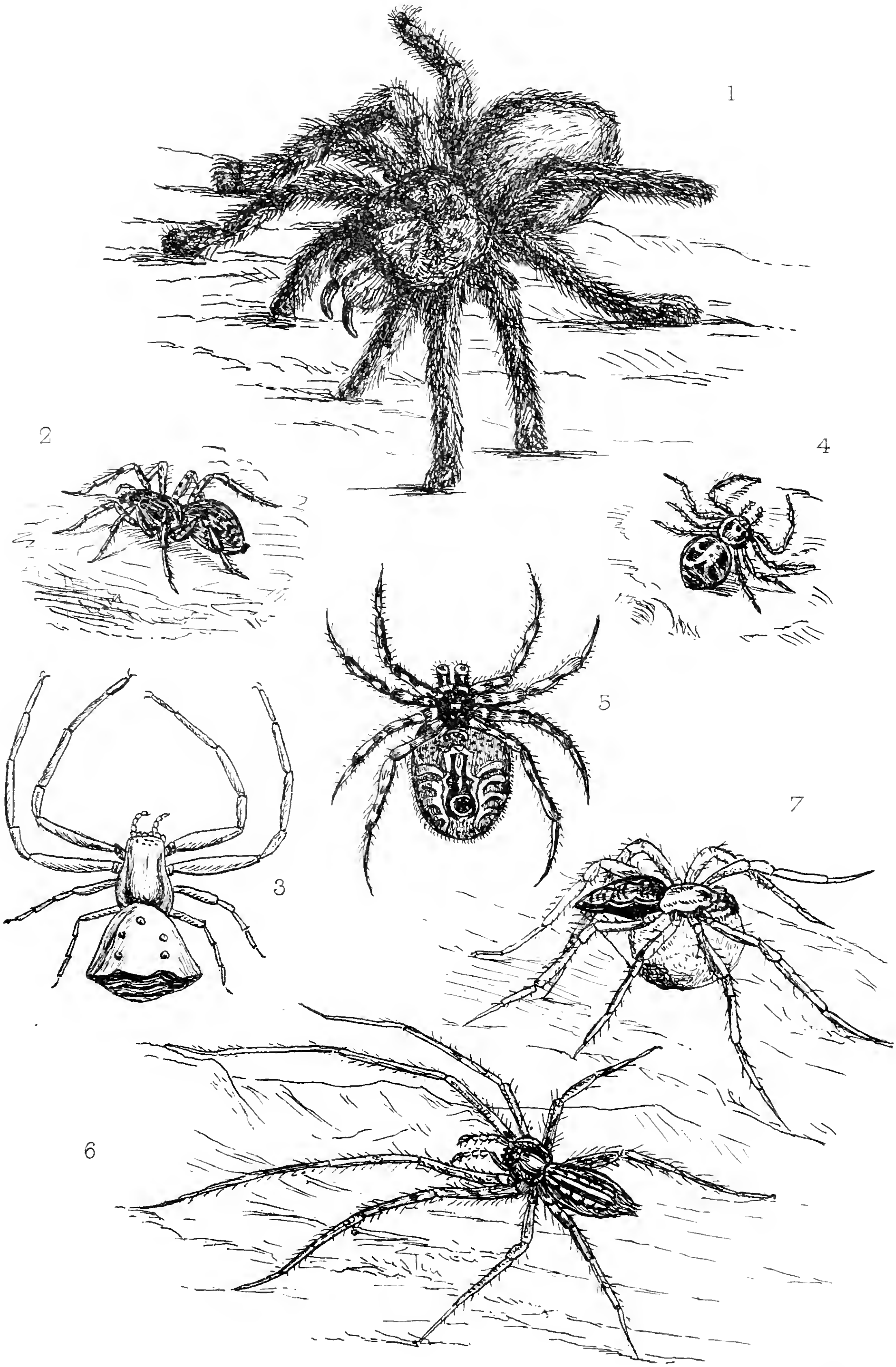
THE following evidence relates to about 220 recorded cases of extra legs, antennæ, palpi or wings, and speaking of cases in which the nature of the extra parts could be correctly determined, it is found that the following principles are followed (amongst others):—

I.—Extra appendages arising from a normal appendage usually contain all parts found in the normal appendage peripherally to the point from which they arise, and never contain parts central to this point.

II. A.—Extra appendages of double structure are the commonest. 1.—Whether separate or in part compound, they consist of *a pair of complementary parts, one being right and the other left.* 2.—Of the two extra appendages, that which is adjacent to the limb from which they arise, *is a limb of the other side of the body.* 3.—If the pair of extra appendages arise from the *anterior* surface of the normal appendage, the surfaces which they present to each other are *structurally posterior;* if they arise *posteriorly*, the adjacent surfaces are *anterior;* if they arise *ventrally*, the adjacent surfaces are *dorsal*, etc.

II. B.—A single extra appendage is rarely perfect. 1.—If it arises from the *body*, it is formed as an appendage of the side on which it is placed. 2.—If it arises by peripheral division of an appendage, the parts central to the point of division are commonly right or left as the case may be, while the peripheral part may be a symmetrical and complementary pair.

These phenomena are important as an indication of the physical nature of bodily symmetry, and in their bearing upon current views of the character of germinal processes.— *W. Bateson.*



F. Phillips, Sc.

Norman Collie, Ph.D., F.R.S.

(Kindly lent by the Editor of "The British and Colonial Druggist.")

The Discovery of Argon and Helium.*

By J. Norman Collie, Ph.D., F.R.S.,
Professor of Chemistry to the Pharmaceutical Society.

IN the early days air was looked upon as an elementary substance, and for many hundreds of years it was considered one of the four elements—earth, air, fire, and water being the four. These elements were not looked upon quite in the same light as we look upon elements nowadays. They had more to do with the properties of substances in general, and not with actual elementary substances, and it was not till about two hundred years ago that definite ideas began to be collected on the subject of air, and it was due to an English chemist—I think many of the great discoveries in chemistry have been due to English chemists—that our ideas on the subject of air first began to take a definite form. It was towards the end of the seventeenth century—over two hundred years ago—that Robert Boyle, an Englishman, first of all published a work on the air, and the various subjects which related to the air. I have a slide here which I should like to show you of a portrait of Robert Boyle himself. I should like to show you the portraits of several of those chemists who worked on air, and who brought the knowledge that we possess of air up to the beginning of this century. Robert Boyle, the first I will mention, was a chemist who investigated not only air, but a great many other substances besides, but he was particularly interested in air and its various properties. He had rather vague notions, however, on the subject of air, but he was one of the first chemists who combated the old idea of earth, air, fire, and water being elements, and he specially points out that there is no reason why we should in any way limit the number of elementary substances to four, and no reason why air should be an elementary substance; in fact, he seemed to think there were a great many different kinds of air, as they were called in those days—"gas" being a much later term, and that the different kinds of "gases" he investigated

* Lecture delivered before the Pharmaceutical Society. From the *Pharmaceutical Journal.*

depended upon the various properties of the substances from which they were produced.

The next portrait of a chemist who had to deal with air is also that of an Englishman named John Mayow. He was a doctor who lived about the same time as Robert Boyle, and he also published some work on the subject of air. He proved that there was no doubt one particular substance present which he called fiery air, and that it was due to this fiery air, which was present in ordinary air, that enabled substances to burn. This was of very great importance, but was lost sight of for more than a hundred years. Mayow also pointed out that this particular air, which he called fiery air, was present also in nitre or saltpetre, and in this way he discovered facts which were re-discovered very much later by a French chemist named Lavoisier at the end of last century.

The next English chemist who had to do with air, and also made a very large number of experiments, was a clergyman of the name of Stephen Hales. He was more interested in the rise of sap in plants and similar substances, and investigations of that description, but he also made a very large number of experiments on heating substances in closed vessels, collecting various airs or gases, as we call them now, above water. He also proved that probably air contained more than one particular kind of air, and he examined the different airs which were produced by the decomposition of all sorts of substances by heat and otherwise, collected them above water, and made investigations on them, but, again, his investigations seem rather to have been lost sight of, and not to further science in any very great way. Air was still looked upon by the chemist as an elementary substance, and not a substance which was composed of different kinds of matter.

About a century later than these three chemists came some more English chemists, who still further advanced our knowledge on the subject of air. This is a portrait of Dr. Black. Dr. Black lived in Edinburgh, and he was the first to point out that there was present in the air what he called fixed air, because he was able to absorb this air from the atmosphere by means of such substances as caustic potash, and also quicklime. He thought by this process the air became fixed or absorbed by these solid substances—the

potash and the lime—and proved that after it had been fixed or absorbed in that manner it could be produced again either by the addition of acids or by heating. He was the first to prove conclusively that a substance named carbonic acid, or, as he called it, fixed air, was present in the atmosphere, and this was really one of the first noticeable facts in our knowledge of the air.

This is a portrait of another Scotch chemist, of the name of Rutherford. He did not, however, study chemistry very completely, and he did not study it all his life, but he is the discoverer of one of the constituents of air, which he called mephitic air, and we now know it by the name of nitrogen. It is that gas which is present in the largest proportion in air; about 80 per cent. of air, or four-fifths, being composed of this gas nitrogen, and Rutherford was the first to point out that this mephitic air was different from the fixed air that Black obtained; also, that it would not support combustion, that substances would not burn in it, and also the more important fact that it would not support life—that animals died in it. Rutherford, therefore, was the discoverer of nitrogen. After having absorbed the other gases in the air by means of various heated substances which absorbed them—such as oxygen and so on—he obtained this gas nitrogen.

The next portrait is of another English chemist of the name of Dr. Priestley. He was the discoverer of the other chief constituent of air. About 120 years ago he obtained oxygen in the pure state for the first time, and proved that this gas, which he called dephlogisticated air, was present in ordinary air, and that it was due to this gas that animals could live in ordinary air, and also that substances burnt very much more brilliantly in pure oxygen or pure dephlogistic air than in ordinary air. That brings us to the end of the last century, and these are the people who had, in fact, most to do with the discovery of the various gases in the air. Black discovered the carbonic acid, Rutherford the nitrogen, and Dr. Priestley the oxygen, the oxygen and nitrogen being the two most important constituents in the atmosphere.

This portrait is a portrait of the French chemist Lavoisier, and perhaps in a way he was greater than all of them. It was Lavoisier who gathered up all these scattered details; it was Lavoisier who put them together; and from the absolute—one might almost

call it—ruin of the old theory (the phlogistic theory) he built up a new edifice on which the modern system of chemistry stands. He explained, first of all, the way we now accept the true theory of combustion. He showed us how it was that substances were burnt in air, and what happened when they did burn in the air—that they absorbed the gas oxygen which was present there, and in doing so gave out light and heat, and he built up the whole theory of combustion such as we understand it at the present day. He took up all the facts the other chemists had discovered, and turned them to his own use and that of chemists in general.

The last portrait I have to show you is that of another Englishman. This was Henry Cavendish, who was by far the most accurate worker of them all. Cavendish without doubt obtained this gas that I am going to tell you about, named argon, and later on I will tell you how he did it. At present I will only mention that he was the discoverer of the composition of water as well. His analyses of air are almost as accurate as the most accurate analyses ever made, and they were made by the most incomplete and most inaccurate pieces of apparatus.

All this brings us to the beginning of the century, and clears the way for what I have now to tell you about the discovery of the gas, argon. At the beginning of the century people thought that they knew all about the air, and that there was no more to know; that all the gases had been discovered, and that there were no more to discover; but it was only two years ago that there suddenly burst on the world this wonderful discovery of the gas, argon. Of all the places to find it, in the air was the most unlikely, for, as I have said, every chemist thought the very last had been said on the subject of ordinary air. The reason that argon had not been discovered before was that all analyses of air had been conducted in the following way:—

First of all, impurities such as water vapour and carbonic acid had been got rid of by absorption; there was then left merely pure oxygen and nitrogen, then the oxygen was absorbed, and the nitrogen was left, no easy method of absorbing nitrogen being then known. The residue was supposed to be pure nitrogen, but, as it so turned out, the residue was by no means pure nitrogen—it contained over 1 per cent. of this gas, argon, which had never been

separated out from the nitrogen before. This discovery, like a great many discoveries, although it burst upon the world and people heard nothing about it until they suddenly heard that the gas had been discovered, was a discovery which had been built up step by step. Few discoveries are made suddenly; they usually come by hard, persistent scientific work, and argon is no exception to that rule, whilst helium is no exception either.

The work which led up to this was due to some excessively accurate work that Lord Rayleigh had been carrying out on the actual densities or weights of given volumes of various gases. About ten years ago he started weighing oxygen and hydrogen, trying to get them as pure as possible, and to find out exactly to the third and fourth place of decimals what a given volume of these gases weighed. After he had done this, in the year 1892 he prepared nitrogen from a great number of different sources, and he found that so long as he prepared nitrogen by chemical process, by the decomposition of ordinary nitrogen compounds, the nitrogen always weighed exactly the same. When, however, he prepared his nitrogen from air by purifying the air and absorbing everything in it except the nitrogen, this nitrogen present in the air did not weigh quite the same, but very nearly the same, as the nitrogen obtained from other sources. These results would, in the hands of most people, have meant nothing; but Lord Rayleigh had spent many years at the work, and he was quite certain that this was due to something he could not explain. First of all, he thought it was the chemical impurities that were present, and he tried his best to get rid of every impurity, still he found that this nitrogen which was obtained from the air was too heavy by a very little, but still it was too heavy, and he was extremely puzzled and could not find out what the reason of it was; so he put the matter in the hands of Professor Ramsay; he and Professor Ramsay joined forces, and then came the discovery of argon. It was perfectly simple. It was the nitrogen which now had to be absorbed. A residue was left, and that residue was argon. The difficulty, however, was to absorb nitrogen, because no substance easily absorbs nitrogen, and the way in which it was done was by means of magnesium. Magnesium absorbs nitrogen very readily at a red heat, and after it has been heated for a long time, and the

nitrogen gas passed round and round over the magnesium, then finally there is a residue left, and that residue is argon. I have a slide here showing the various densities of these gases that Lord Rayleigh obtained.

The way in which nitrogen was absorbed afterwards, when it got down to a small bulk, is shown on the next slide. The water in the vessel contains caustic soda. There are two platinum points connected by wires to an apparatus for making sparks. If gas containing the last traces of nitrogen, which is difficult to be got rid of by means of magnesium, is introduced into such an apparatus with oxygen, and the electric spark be allowed to pass between the two points *b* and *d*, the nitrogen will combine with the oxygen and form a substance which can be absorbed in the soda solution. That is the way of getting rid of the last traces of nitrogen; and there are then left only argon and oxygen; the oxygen can be absorbed by any ordinary re-agent, such as phosphorus.

The next slide shows a rather more elaborate apparatus for dealing with a larger quantity. The electrodes here dip down so as to touch the surface of the liquid soda. That gives a larger space, and combination takes place more readily. To keep it cool Lord Rayleigh had occasionally a spray of soda running up to cool the top of the vessel. It is an improved apparatus for working on larger quantities.

The next slide shows a still further improvement in the apparatus. This is one in which the electric spark is allowed to play between the two tubes. The section shows the bath, which is cooled by means of water.

Next comes a diagram which shows the apparatus that Professor Ramsay used first of all for the absorption of nitrogen. It contains various absorbents for absorbing nitrogen and other gases present in ordinary atmospheric nitrogen. Starting at *A* by letting water run in, the gas is sent through the whole apparatus into *B*, and when it gets there it can be sent back again into *A*, and so it may be passed backwards and forwards. In the various parts of the apparatus are phosphorus pentoxide to dry the gas, copper to get rid of the oxygen, copper oxide to get rid of the hydrogen, soda and lime to get rid of the acid vapours, and

metallic magnesium ; thus, all the various impurities in the gas are absorbed, and finally only argon is left.

The next diagram represents apparatus for conducting operations on a larger scale. It is an automatic arrangement for making the gas circulate round and round, and is a very effective apparatus for the manufacture of argon on a large scale.

After argon had been obtained in this way, the difficulty was to find out how it differed from other substances, and unless chemists had been able to make use of the electric discharge through a gas they never would have been able to find out that this argon was different from ordinary nitrogen or any other element. A great many substances are able to give out light when they are subjected to the electric discharge, and I will now show you three extremely beautiful experiments, by means of apparatus lent me by Mr. Jackson, of King's College. The first will show you how a solid emits light when submitted to an electric discharge, the second a liquid, and the third a gas, and in each case you will find that we get a very beautiful light given out. In this vessel I have some ordinary lime, made by igniting bits of calc spar. I will connect it with a battery producing sparks, and when I turn on the current we shall find this solid produces a most beautiful light.

The next experiment deals with a liquid, a solution of sulphate of quinine, which you will see gives out a beautiful blue light.

Finally, I will take a gas and show you how we can, by passing an electric discharge through it, get it to light up just in the same way as the solid and the liquid. It is a long tube filled with air; in its normal condition it gives no light, but it is connected with an air-pump, and as I gradually exhaust the air you will see how the light begins to appear, and increases as the vacuum becomes more perfect. When I turn the stopcock and allow air to enter it diminishes, and finally disappears. If it had not been for the power of lighting up gases in that way by electricity, it would have been extremely difficult to detect argon in small quantities.

All gases can be lit up by means of the electric current, if they are exhausted to a sufficient degree of rarity. I have several tubes here containing different gases, which I should like to show you. Some contain air, one contains hydrogen, and one carbonic acid, and each gas gives a different kind of light.

Now I will show you a tube of the gas argon. Argon can be made to give out two different kinds of light when excited by means of the electric current—one a purple and the other a beautiful blue. I will first show you the purple. That tube is the historic argon tube. It was lent me by Professor Ramsay, and is the one which was used for the measurement of the argon lines by Mr. Crookes, and is the one which has been shown at all the different exhibitions of argon. It owes its beautiful colour to its long life. There are very few argon tubes which give anything like the brilliancy of this; in fact, I believe there are none, because there are none so pure. By this incessant violent knocking of the atoms of the gas against the sides of the tube and against each other, it becomes purer and purer, as the other gases get absorbed by the electrodes, which are made of magnesium, so that this is a perfectly pure sample of argon inside the tube. Now, I want you to see the wonderful change that takes place in the argon light the moment I put a Leyden jar with a spark-gap into the circuit. It now becomes a beautiful blue colour.

This light was examined by the spectrum and found to give out various lines, which showed that it was different to any other gas. It was also found on weighing the gas that it was heavier than ordinary nitrogen, being twenty times heavier than hydrogen, whilst ordinary nitrogen is only fourteen and a half times heavier, and therefore the discovery was put on a firm basis at once.

Now, we come to the other new gas, helium, which was the direct outcome of this piece of work on argon. The gas which is given off when certain minerals are dissolved in acids is usually carbonic acid, and there was a curious mineral which Professor Ramsay's attention was called to, which is found in America and also in Sweden, called cleveite. An American chemist named Hildebrand had worked at it and got a large quantity of gas from it, and on examining it carefully he came to the conclusion that it was nitrogen. Professor Ramsay's attention was called to it in order that possibly he might be able to prove that it was argon, for it was a very curious thing for a mineral to give off nitrogen. Professor Ramsay, immediately he heard of it, obtained some of the mineral, dissolved it in acid, heated it, and got the gas off. It was on a Friday afternoon that a tube was filled and looked at

through the spectroscope. The first thing we noticed was a magnificent brilliant yellow line. The next week Professor Ramsay was going over to France to give an address to the Académie des Sciences in Paris on argon. When on the Friday afternoon we examined this gas from the cleveite, the brilliant yellow line at first suggested the element sodium, for it looked exactly like the sodium line, which is a yellow line, or rather a double one. I at once said the tube must be very dirty. Professor Ramsay said, however, "it is perfectly clean, but it is perfectly easy to test it. Produce the yellow sodium line and compare it, and if the two lines coincide then it is sodium; if not, it is something else." This was done, and at once we saw that it was not the sodium line, for it was on one side of it, and at once helium was suggested. The reason for that was, that about thirty years ago, during an eclipse of the sun, Professors Frankland and Norman Lockyer made a large number of photographic and spectroscopic examinations of the corona—*i.e.*, the extreme outside of the sun, the part which is seen only during eclipses, where great volumes of incandescent gases are shot out hundreds of thousands of miles in great tornadoes. These examinations of the sun's corona revealed a brilliant yellow line. This yellow line was unknown at the time and corresponded to no known element on the earth, so Norman Lockyer suggested calling it helium. It had been seen at this particular part of the sun. It was of interest, because only the very lightest gases such as hydrogen existed there, and here was another gas, which, presumably, was as light as hydrogen—existing in the corona of the sun together with hydrogen.

Nothing more was known of it until, in this gas prepared from cleveite, this yellow line appeared, and we could not be certain that it was helium until we had actually measured the wave-length of that particular line. Professor Ramsay took it up to Mr Crookes that night, and on the Saturday morning Mr. Crookes measured it, and found it was almost, if not quite, identical with the line of helium, D_3; so that Professor Ramsay was able to telegraph over to the French chemist (Berthellet), saying he was coming over to give the lecture on argon, and that he had discovered another new element, helium, which he would bring over with him.

This element, helium, has a most magnificent, brilliant yellow spectrum; in fact, the spectrum of helium, and the colour it gives out when subjected to the electric discharge are by far the most beautiful of any gas that I know; far more brilliant than hydrogen; far more brilliant than any ordinary gas; and if we examine it by means of the spectroscope it almost seems as if the whole of the most striking spectra had got mixed up together and put into one tube. There is a beautiful red line, which is as brilliant as the best red line in the hydrogen; there is a magnificent, intensely bright yellow line; and, moreover, there are green, blue, and purple ones. All these lines exist in the helium in the most wonderful manner. If you look at it through a spectroscope you see a most magnificent spectrum.

There is but little more time to tell you about these gases—that is, about their general properties, and I have also not told you about the preparation of argon by Cavendish, but that will not take very long. What he did was this:—He actually absorbed all the nitrogen by means of sparking, and I have here a diagram of the apparatus he used. It is perfectly marvellous that he was able to carry out the experiment with a couple of wine-glasses, a bent tube, and some potash lees, and an ordinary electric machine, and that was all Cavendish had when he produced argon. He took the nitrogen and put it into the bent tube above mercury; he then introduced, by means of a pipette, certain quantities of oxygen, and sparked them with a wire introduced here from an ordinary electrical machine. In that way he was able to get the very feeble electric spark which could be obtained from the electrical machine of those days to pass from the level in one tube of gas down to the liquor in the other tube. Then he added more oxygen and more nitrogen, and went on thus keeping the machine going for about two months, probably for twelve hours a day, and was able to get the gas absorbed slowly; and, lastly, by a little liver of sulphur in this tube he absorbed the last traces of oxygen, and there was a minute bubble of gas left, and so accurate had he been with his measurements that he said: "After I had done this there was left a small bubble, but whether that was due to another constituent of the atmospheric air or not I was not able to say. At any rate," he said, "if this is a new constituent of the atmo-

sphere, it is only present in the proportion of the 1/120th part of the original atmosphere that I took." He was very nearly correct. It is a little over 1/100th. About 1 per cent, of the atmosphere is argon, and Cavendish said it could not be more than 1/120th. If Cavendish had been able to use such electric apparatus as we have nowadays, and such tubes as we have, that gas would have given all the spectra we now get from argon. But spectroscopy was not invented until about eighty years later, by Bunsen and Kirchoff.

This diagram shows the apparatus used for the liquefaction of argon. Some argon was sent to a Polish Professor, Olszewski, who has worked on the liquefaction of gases. He, by surrounding a tube filled with argon with liquid oxygen made to boil in a vacuum, succeeded not only in liquefying, but in solidifying argon. Argon boils at $-187°\cdot0$ C., and becomes solid at $-189°\cdot6$ C.

This table shows the boiling points of different gases. $-246°$C. is the temperature at which hydrogen boils; nitrogen $-194°$ C. Helium is not given here because it was not discovered when this table was prepared, and helium is the only gas which up to the present has not been liquefied. The absolute zero temperature, below which theoretically nothing can be cooled—that is to say, the temperature at which we suppose any substance ceases to possess any heat at all, and, therefore, cannot lose any more heat —is $-273°$ C. Professor Olszewski has cooled helium by boiling liquid hydrogen down to $-266°$ or $-267°$, within a few degrees of absolute zero, and yet has not liquefied it, even under pressure, and therefore it probably will not be liquefied.

Just one word in conclusion about the discovery of these gases. I mentioned at the beginning that no discovery is made except by hard work, and that no discovery is made suddenly. The whole of our knowledge about argon and helium came from hard work, and it came step by step; one thing led to another. No one would ever have thought of looking at cleveite as a mineral from which helium might be discovered, unless first of all argon had been discovered, and no one would have thought of argon unless Lord Rayleigh, by accurate work, had found that the nitrogen that came from air was a little too heavy. He would not have done that unless he had been instigated to perform some rather more

accurate scientific work than had been done by others; he merely repeated other people's work on the density of gases, because he wished to get more accurate determinations, in order that from those data other data might be obtained.

I think that probably the discovery of argon and helium, although at present they are of no commercial use—and I may say that people often ask me what is the use of argon and helium, but as it is difficult to answer such questions, I do not try—from a scientific point of view, helium probably will be of the very greatest use. It is a gas which has the most peculiar properties. It is a gas which we call monatomic—that is to say, its atoms are the same as its molecules; the molecule and the atom are identical. Again, the electric conductivity of helium is very much greater at ordinary pressure than that of any other gas that is known. (Several experiments were here shown to prove this, the electric spark traversing a helium tube in preference to one of air or hydrogen, or passing through a longer distance.) Helium is ten times as good a conductor of electricity as ordinary air. Hydrogen up to the discovery of helium was the best conductor, but it is inferior to helium. Another curious point about it is that it is extremely light, and diffuses through a porous septum much more rapidly than it has any business to do. It diffuses in a perfectly abnormal way. Therefore I think this gas ought to be very useful to the physicists. They often talk about a perfect gas, and now I think they have it, and I hope they will be able to make something out of it. Chemists have done much with it, and now it is the turn of the physicists.

I have now taken up enough of your time, and hope I have been able to make myself sufficiently plain, and that you now know a little about the discovery of these two gases, argon and helium.

TO CATCH EARTHWORMS.—According to *Nature*, earthworms may be obtained in any quantity without the labour of digging by watering the ground with a solution of sulphate of copper of a strength of 1 per cent. This will bring the worms to the surface almost immediately. Soap-suds are said to produce the same effect.

British Hydrachnidæ.

By Charles D. Soar. Part VII. Plate III.

In the present paper we purpose considering two somewhat similar genera of *Hydrachnidæ*, the first to which we shall direct attention being the Genus *Limnesia* (Koch).

1842.—C. L. Koch, *Übersicht des Arachnidensystems*, p. 3, p. 27.

Mites belonging to this genus are characterised as having the body soft-skinned; legs well-supplied with swimming hairs; fourth pair of feet without claws; three genital suckers on each side of the genital fissure; epimera in four groups; palpus not chelate; mandibles in two portions; eyes wide apart.

The members of this genus differ from any others which have been previously considered in being without ungues to the tarsus of the fourth pair of legs; it is a genus easily recognised when once seen. There is only one other genus that is likely to be mistaken for it, viz., *Teutonia* (Koenike); but the difference is very observable when once it has been pointed out. We shall describe the genus *Teutonia* later on in this paper. All the species of *Limnesia* with which I am acquainted show very little difference in structure, the male and female being very much alike, the only remarkable feature being the shape of the genital plates, as shown in Plate III., Figs. 3—5. In size the males are a little smaller than the females, but they do not possess that peculiar spur on the fourth pair of legs, so commonly met with in *Arrenurus*, *Axona*, and others, to which attention has been drawn in previous papers.

There are several British species; some are very common, and exhibit a great variety of colours, ranging from deep red to pale yellow; they can be found almost anywhere in ponds, lakes, or rivers. They will live a long time in confinement; I have frequently kept them, both in summer and winter, for several months at the time, but I have not been so fortunate as to have any ova deposited either in the tanks or in the tubes in which I have kept them.

They are very much like the spider family in the way they prey on the other life in the same tank, and when that is exhausted

they prey on one another. It is not safe to put other soft-bodied Hydrachnids into the same tank, unless they are intended as food, for the *Limnesia* make very short work of them, and extract their life's blood in a very short time ; *Eylais extendens* appears to be a particularly dainty morsel, and specially adapted to their taste.

Not having been successful in breeding, although I have kept the adults so long at the time, I am unable to give a figure of the larva. Dr. George tells me he also has had no better fortune than myself, although he has kept them in confinement for a considerable length of time ; it may be they do not deposit ova at all. Anyhow, it is a question which yet remains to be answered. Perhaps accident will at some future time solve the problem for us.

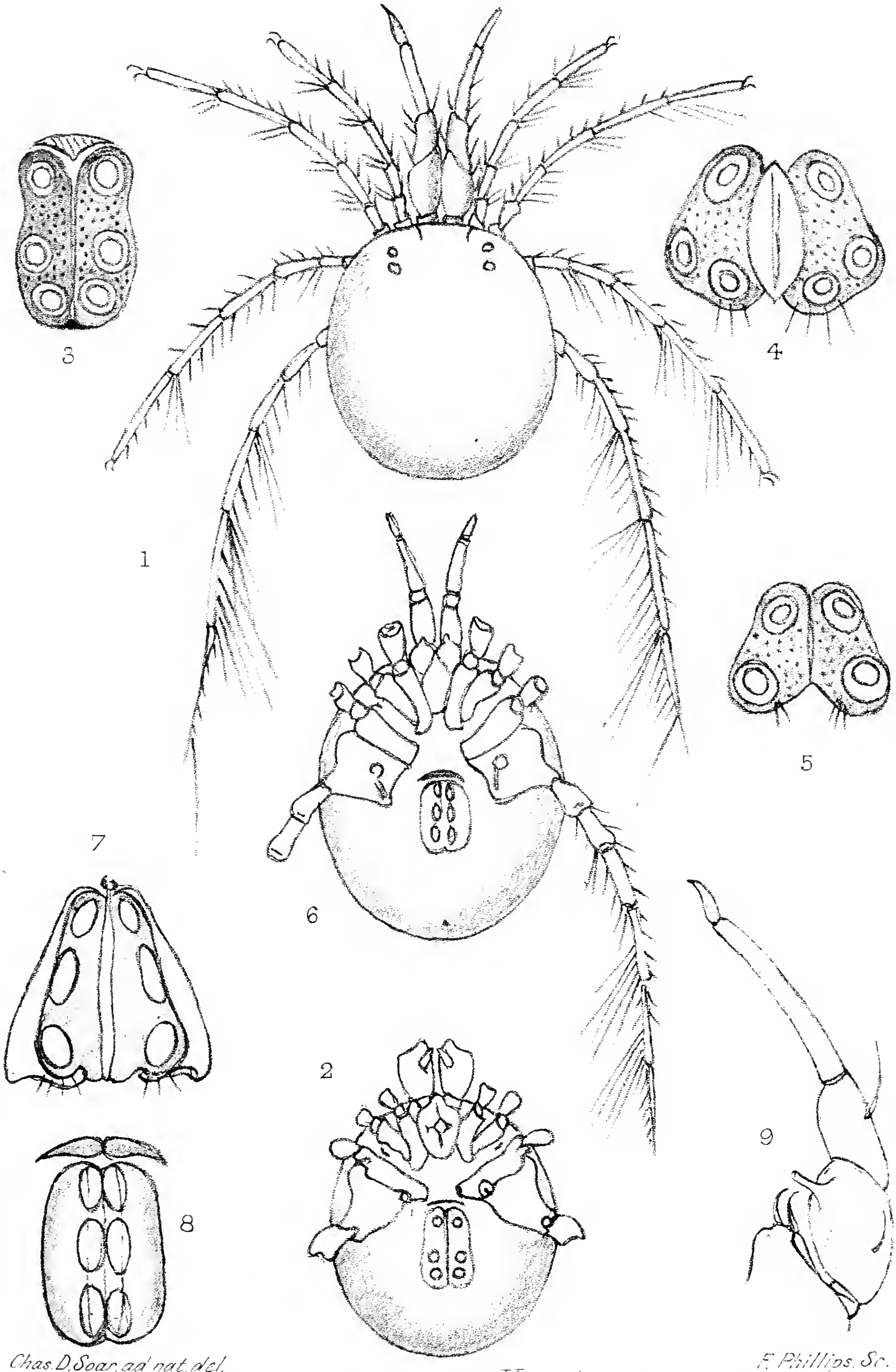
The next stage, the "nymph," I have taken a great many times in this form. They are much like the adults, but have only four genital suckers instead of six, as shown in Fig. 5.

Limnesia longipalpis (Koch).

1835—41.—C. L. Koch, *Deutschlands Crust.*, etc., p. 7, Fig. 8.

There can, I think, be no mistake about this species being correctly named *longipalpis*, for the palpi is certainly very long ; in more than one specimen I have found the palpi longer than the first pair of legs. Koch gives a beautiful little figure of this mite, but it is coloured yellow, whereas all those specimens which I have found have always been bright red, with pale blue legs. But colour only gives us a variety ; it does not constitute a species. So we must not consider the colour, but look only to the structure for the identification of species.

The length of body is about 7/150ths of an inch. The only district in which, to my knowledge, it has been found in Britain is N. Wales. Mr. Scourfield sent me several specimens from Llyn-Guetnar, Dolgelly, N. Wales, in June, 1895, and I took about a dozen more specimens in Llyn-Padarn, and in a small lake near Newborough, Anglesey, when collecting with Mr. Scourfield in September, 1896. It may be very common in all lake districts, but up to the time of writing, the above are the only localities in which I have known them to be met with.



Chas. D. Soar, ad nat. del. F. Phillips. Sc.

Limnesia longipalpis (Koch) Fig. 1–5.
Teutonia primaria (Koenike) Fig. 6–9.

GENUS VIII.—*Teutonia* (Koenike).

1890.—F. Koenike, *Archiv. f. Naturgesch.*, p. 75.

The characteristics of this genus are :—Body soft skinned; legs well supplied with swimming hairs; fourth pairs of feet without claws. Three genital suckers on the inner edge of the genital plates on either side of the genital fissure; epimera in four groups; palpi not chelate; mandibles in two portions; eyes wide apart.

This genus, as has been already remarked, is very closely allied to the *Limnesia*—so much so, indeed, that it can easily be mistaken for it; but it will be noticed in Figs. 7—8 that the genital suckers are on the inner side of the plate, and not on the plate itself, as is the case in Figs. 3—4 of *Limnesia*. The posterior pair of epimera are also more square, as shown in Fig. 6. The rostrum is also projected a little more forward, and the palpi are attached to that part, much in the same manner as we shall find in *Sperchon* (Kramer). In *Limnesia* will be noticed on the fourth pair of feet, or rather the tarsi, a long spine projecting outwards, which I have never seen in *Teutonia*.

Teutonia primaria (Koenike).

1890.—F. Koenike, *Archiv. f. Naturgesch.*, pp. 76—80, Pl. V.

This is, I believe, the only species known of this genus up to the present time. It is pale yellow in colour, with brown markings. I first took it in 1893 at Bealings, Suffolk; but not having at that time seen Koenike's paper, referred to above, I believed it to be a strange species of *Limnesia*. In June, 1895, I took two more specimens at the same place, and this year in North Wales I took several more, so in all probability it is fairly common; but I have never taken it in any of the usual collecting grounds round London. It measures about 1/25th of an inch in length. The palpus has the same peg-like process which is always found on *Limnesia* (see Fig. 9).

EXPLANATION OF PLATE III.

Limnesia longipalpis (Koch).

Fig. 1.—Dorsal surface.

,, 2.—Ventral surface.

Fig. 3.—Genital area of female.
,, 4.—Genital area of male.
,, 5.—Genital area of nymph.

Teutonia primaria (Koenike).

,, 6.—Ventral surface.
,, 7.—Genital area of male.
,, 8.—Genital area of female.
,, 9.—Palpus of female.

Observations on the Morphology of Species of the Genus Ulex.

By Harold Wager, F.L.S. Plates IV. and V.

THERE are two species of *Ulex* to be found in England, *U. Europæus* and *U. nanus*, and a variety of the latter known as *Gallii*, both common in most parts of the country, and familiar plants to all who are acquainted with our heaths and commons. Although apparently so distinct in the structure and general appearance of its vegetative organs, we may compare the genus *Ulex* with the genus *Cytisus*, which it resembles in many respects in regard to its morphological characters. In *Ulex* we have what may be regarded as an extreme modification of vegetative structure in response to the environment, which in *Cytisus* is not so far advanced, and in the following pages we shall endeavour to describe this modification, how it has probably been brought about, and under what conditions.

The commonest species, *U. Europæus*, is distributed very widely, being found in the western parts of the old world from north-west Africa to Shetland Islands, and ascending to a height of 2,100 feet in Wales. It is a shrubby bush, about three to five feet high, with a very compact habit when grown in the open, but a rather straggling habit when grown in the shade. This compact habit is due, in large part, to the regular mode of branching which it possesses and to the development of short spiny branches in the axils of the leaves. The plant likes deep and somewhat loamy

soil, and is sensitive to cold. This can be readily seen by the number of plants killed during our cold winters. After the severe winter of 1894—5 so large a number of dead bushes could be seen in all the more exposed situations that it was a matter of considerable astonishment to those who imagined that such stiff, tough plants must be very hardy.

The general structure of the vegetative organs presents many features of interest; the leaves are reduced practically to spines, and their function of assimilation is to a large extent replaced by that of the stem. The internal structure of the spiny leaf remains similar, however, to that of ordinary foliage leaves, except that it has a tendency to develop palisade tissue all round. The leaf is leathery, the epidermis is very thick, and the stomata are slightly sunk in it. In the axils of nearly all the leaves short branches occur, of varying length, each terminated by a strong spine. These may be termed the *primary spiny branches;* they grow for one year only, and produce in most cases a small number of leaves which may have *secondary spiny branches* in their axils. In addition to these branches, others are produced, with a similar structure, but longer and having a different origin. They are always developed between the foliage leaf and the primary spiny branch. They generally terminate in spines, but in some cases continue to grow at the apex by means of an apical bud. They are called *accessory branches.* When these branches are fully formed, the primary spiny branch and the leaf at its base turn brown and die, as can be easily observed by anyone who cares to take the trouble to examine a furze bush of more than two years' growth.

If we examine a branch of Furze two years old, we shall see that it is covered with accessory branches from the base to the apex, but they are longer and more numerous near the apex, where they form a tufted group radiating in all directions, than lower down. In a favourable specimen all the upper leaves bear such accessory branches in their axils. Nearly all the primary spines and leaves at the bases of the accessory branches on such a stem will be found to be withered, with the exception of those which are fairly well exposed to light. Very few of the accessory branches continue to grow for more than one year. They nearly

all terminate in spines. In one specimen taken at random, out of fourteen well-developed branches, only one terminated in an apical bud. Even when present, however, the terminal buds do not often pass through the winter, being generally so sensitive to cold that they are killed by a fairly sharp frost. Some few occasionally are seen to survive the winter, and these continue to grow during the next year. Where accessory branches are not visible or apparently not developed, rudimentary branches will be found in the form of buds placed in the same position, between the follage leaf and the primary spine, ready to grow should an opportunity be given them, and protected against injury by being carefully packed between the two and surrounded by scale leaves covered with hairs.

The accessory branches have the same structure as the main axis. They bear in their turn primary spines and accessory branches, and these latter again branch in the same manner. As they never grow very long and generally only for one year, we get the compact habit of the plant, which has been already mentioned.

The flowers are generally borne on the primary spines, but at the apex of the accessory branches they are produced directly in the axils of the leaves in place of the primary spines ; and on the primary spines themselves the flowers replace secondary spines. They are only formed on those parts of the plant which are more exposed to light than the others. This may be illustrated by observations on a short branch taken at random from a furze plant. In this case there were no flowers at all at the base, as this part of the branch was completely surrounded by other branches. The first flowers were produced at a distance of 12 cm. from the apex on the primary spines. Starting, therefore, just below this, and taking branches here and there as we pass upwards to the apex, we find a regular progression in the number of flowers produced, as the primary spines become more fully exposed to light :

Branch 1.—Seven leaves, all with secondary spines in their axils. No flowers.

Branch 2.—Eight leaves ; the lower six with spines, the two upper ones with flowers in their axils.

Branch 3.—Seven leaves ; first five with spines, the sixth and seventh with flowers.

Branch 4.—Seven leaves; one to three with spines, four to seven with flowers.

Branch 5.—Ten leaves; one to three with spines, four to ten with flowers (Fig. 14).

Branch 6.—The nearest branch to the apex with five leaves, all with flowers in their axils.

The secondary spiny branches also bear leaves with flowers or tertiary spiny branches in their axils, and these appear to follow the same rule. In Branch 2, for example, I found the secondary spiny branches in the axils of leaves one to three, with two foliage leaves, right and left at the base, and in the axils of each a spine. On the secondary spines, four to eight, I found two foliage leaves on each, in the same position as above, and in the axils of all were flowers. On Branch 5 I found that, of the secondary spiny branches, one to three, each produced two foliage leaves at the base, and the third branch a third foliage leaf in addition. One leaf on each of the spines numbered one and two had a tertiary spine in its axis; the other leaf a flower. On spine No. 3 the two lower leaves had flowers, the upper leaf none, being only very small.

The primary spines vary considerably in length according to their position, being longest on those parts of the plant which are well exposed to the light and shortest on those parts which are hidden by the surrounding branches. If a Furze bush be examined carefully, it will be seen that the length of both primary spines and secondary branches varies regularly according to the amount of exposure to light, and, further, the arrangement of the various primary, secondary, and tertiary spines and leaves is such that the largest surface of assimilative tissue is exposed to light with the smallest amount of overlapping, so that the light can filter down from the higher to the lower portions of a branch without any serious interruption.

According to Wydler, two cases of leaf arrangement obtain on the primary spines. In the first case, there are two leaves at the base standing opposite one another, and at right angles to the foliage leaf, in the axil of which the spine is borne (see Fig. 14). These are followed by a leaf higher up on the branch, and on its upper surface exactly midway between these two (Fig. 14).

From this leaf starts a 1/3rd cycle of leaves, which may pass into the 3/8 cycle.

In the second case, the median leaf, as above, initiates at once a 3/8 arrangement without passing through the 1/3 cycle. I find, however, that this arrangement is not constant. It varies as the length of the spine and the number of leaves it produces. There is a tendency to the production of leaves arranged in whorls or groups of two or three, which modifies considerably any given cycle.

The arrangement of the leaves on the accessory branches differs somewhat from this. According to Wydler there are two cases. In the first case, the four first leaves are produced in pairs at right angles to one another; then follows a 1/3 cycle, succeeded by the 3/8 arrangement. In the second case, the 3/8 arrangement follows at once on the two pairs of leaves. My own observations generally support Wydler's, but in some cases the number of pairs of leaves at the base is more than two, and in other cases the leaves are not developed in pairs at all, but start at once with a spiral arrangement.

The general structure and arrangement of the leaves are the same in *U. nanus*, var. *Gallii*, as in *U. Europæus*, and calls for no detailed description here. For comparison, I will shortly describe a branch, 80 mm. long, taken from among about sixteen others, growing in a group on the main axis of a fairly strong plant of several years' growth. Starting at the base were six short spathulate leaves, about 3 mm. long, with no branches in their axils. These were growing in a shady position. Then followed a number of spathulate leaves, with a slightly developed spine at the apex. On following these leaves upwards, they were found to vary in length from 4·5 mm. to 7 mm., at the same time becoming more distinctly spiny, and were succeeded by leaves gradually decreasing to 2·5 mm. in length, with a well developed spiny character and the ordinary structure of a spiny leaf. Of these leaves twenty-nine had well formed spines in their axils, on the upper five of which flowers were produced. Above these twenty-nine leaves were thirteen others close to the apex with rudimentary spines in their axils, one only possessing a flower. The lowest spine on the branch was 6·5 mm. long and had two lateral leaves,

in the axil of one of which a short spine was produced. The uppermost spine on the branch was 12 mm. long, being more exposed than the lower one, and had four foliage leaves, in the axils of three of which secondary spines were found and in the fourth a flower. The arrangement of the leaves, both on the spines and on the accessory branches, was very similar to that which has been described as occurring in *U. Europæus*, and exhibited the same kind of variation.

This variation in the arrangement of the leaves is difficult to explain, being probably due to many causes, some of which we can perhaps indicate, and some of which we are ignorant. It is determined, first of all, by their development at the apex of the stem, the new leaf appearing just where there is the greatest amount of space between those previously formed. This explains, of course, the formation, at the base of a branch, of leaves in pairs, the two first leaves being developed opposite each other and the succeeding ones exactly midway between them. It depends, secondly, upon the size of the leaves, variation being introduced when the newly developed leaves vary in size from those preceding them. And variation is also probably caused when flowers are produced in the axils of the leaves instead of spines.

The size of the leaf mainly depends, of course, upon the conditions which have caused their reduction to spines, but it also depends to a slight extent upon their situation on the plant, the spiny character not being so well developed in leaves formed in the shade as in those exposed directly to light. We shall, however, consider this question again when dealing with the development of the seedling.

The anatomical structure of the stem is correlated with the reduction of the leaves to spines. As the assimilative function of the leaves is reduced, that of the stem becomes more perfect. In order to effect this, both the normal stems and the spiny branches are longitudinally ridged, so that the amount of stem surface which becomes thus exposed is in extent considerably more than doubled. If we examine a transverse section of a primary spine under the microscope, we shall notice that the ridges are very prominent, with the hollows between them very pronounced (see Fig. 12). The ridges are supported by bands of strengthening

tissue, radiating from the central part of the spine, thickened on the outer edge (Fig. 12, *S*). In the hollows between the ridges we find two or more rows of thin-walled cells, full of chlorophyll corpuscles. This is the assimilative tissue (Figs. 12 and 13, *a*). The epidermis surrounding the stem possesses a very thick cuticle, and the stomata are slightly sunk below the surface. The stomata occur almost exclusively in the hollows of the stem and are protected by hairs (Figs. 12 and 13). Just inside the chlorophyll layer is a single row of large thin-walled cells, with very little contents and no chlorophyll corpuscles; next to these are the endodermis and pericycle, followed by a ring of vascular bundles, one to each ridge (Figs. 12 and 13). The structure of the normal stem resembles this, but the chlorophyll tissue is not so well developed, and secondary thickening takes place at an early stage, so that a complete ring of vascular tissue is seen instead of separate bundles.

The presence of the assimilative tissue in the hollows of the stem only has been explained as preventing a too-rapid evaporation of water, such as takes place when large leaf-surfaces are exposed. It has been suggested that this modification is therefore a safeguard against drought, but Kerner is of opinion that it is merely a contrivance to prevent the wetting of the stomata. That this in part explains the modification is probable; but it seems to me that, in common with many other contrivances of a similar nature—such as rolled-up leaves, needle-shaped leaves, etc.—it is mainly a protection against excessive transpiration. But, so far as I know, the Furze plant, although it is grown in a rather dry soil, is never or very rarely exposed to excessive dryness, and therefore this provision against drought may appear to be of very little use. But drought is not the only cause of excessive transpiration. Cold winds promote transpiration, and at the same time tends to retard the absorption of moisture by the roots. The Furze plant grows in exposed situations generally, and would thus be very liable to be affected in this manner were it not for the reduction of the leaves and the modification of the stem. In fact, even now the Furze is unable to stand very severe cold, and nearly all the young developing buds are killed during the winter. But without committing ourselves to one explanation or the other, we may, I

think, say that this modification of the Furze plant is a protection against excessive evaporation, whether from drought or cold winds.

But what are we to say of the spiny character? It has been pointed out that spines are the direct outcome of the environment of drought. Henslow brings forward many examples to support this from various writers, who all agree that under extreme conditions of dryness plants tend to produce spines, while when spiny plants are grown with an abundant supply of water they tend to lose their spines. A French observer—M. Lothelier—found that on growing a spiny plant, *Berberis vulgaris*, in a damp atmosphere, it bore no spinescent leaves; but in a perfectly dry atmosphere it produced spines only. His figures are certainly very striking and show this clearly.

My own observations on naturally grown seedlings of *Ulex*, to some extent, support this view, for I have found that taking a large number of seedlings from two equally exposed but different soils, one humus and the other stony loam, that the percentage of seedlings with trifoliate leaves is not only greater on humus soil than on the stony loam; but the spinescent character is more quickly assumed in the latter case than in the former, and as the humus soil holds more moisture, as is well known, than the stony soil, it appears as if this were the direct cause of it. Nevertheless, it would not be fair to state definitely that this is so, for there may be many causes at work of which we are ignorant, and one which would at once occur to any careful observer, is whether nutrition does not produce some effect upon young seedlings, the difference between the nutritive values of humus soil and stony loam being at once apparent.

At the same time, observations which I have made upon seedlings kept indoors, well exposed to light, in a sandy soil, and well supplied with water, although perhaps not very conclusive, owing to the short time during which I have been able to continue them, tend to support the view put forward by other observers that the presence of moisture tends to reduce the spinescent character.

A seedling of *Ulex Europæus*, which had germinated in the antumn, and had already produced fourteen trifoliate leaves, was taken the following spring and planted in a flower pot, in sandy loam. It was kept in a warm room well exposed to light for many

months, and was well-supplied with water. The seedling to start with was two centimetres long. The main axis continued growing and developed first of all eight more trifoliate leaves, then six difoliate ones, and then a number of thin, linear, lanceolate leaves, with only a slight rudiment of a spine at the apex. The stem remained thin, and the leaves never became stiff or spiny. This main axis grew to about twenty centimetres long while it was under my observation. In the axils of the upper leaves, spiny branches were produced, but the spines never became prominent, whilst the lateral leaves borne upon them were generally well developed, and in many cases no spine was formed at all. Three of the lower trifoliate leaves developed branches which were respectively 5, 6, and $7\frac{1}{2}$ cm. long. Neither of them had terminated their growth by a spine, and on all of them the leaves remained thin, flexible, and only very feebly spined. In the axils of only a few of these leaves were any spiny branches produced, and these were only very rudimentary, and in no case was the spine developed. The following details of one of these branches may be interesting :—

Leaves 1 to 9.—No branches at all in their axils.
„ 10 and 11.—The two lateral leaves only of the spiny branches developed.
„ 12 and 13.—A small bud only in their axils.
„ 14 and 15. —Two lateral leaves only, no spine.
„ 16 to 27.—Two lateral leaves only slightly spiny, but no main spine.

Under normal conditions, as I was careful to observe, such a seedling would have developed a very definite spiny structure during the few months I had it under observation. The seedling was ultimately killed by an exposure to a couple of months' drought, but the observations are sufficient to show that a good supply of water and non-exposure to cold tends to retard the development of the spiny nature of the plant, not only by reducing the stiff spiny nature of the leaves, but also by reducing the stiff spiny nature of the stem, and allowing a much greater development of length at the expense of sturdiness and the development of leaves which are capable of fulfilling the leaf

function to a much greater degree than the ordinary leaves of a Furze plant. It was interesting to note that the leaves, instead of standing straight out, as is the case normally, were curved downwards in such a way as to expose the largest amount of surface to the light.

Another seedling which I took and planted at the same time was a second year's seedling from the same place. During its first year this seedling had developed a main axis ten cm. long, with twelve trifoliate leaves, four difoliate ones, and thirty-one linear, lanceolate spiny leaves. In the axil of each leaf, except the trifoliate ones, was a spiny branch with a well-formed spine. On being kept in a warm room with a plentiful supply of water, there appeared, in the axils of six of the lower trifoliate leaves, primary branches, which reached the length of 30, 27, 17, 10, 2·5, and 1·5 cm. respectively, being much longer than they would have become under normal conditions. These had already commenced to grow when the seedling was planted, but were then extremely short. The shortest of the branches, 1·5 cm. long only, had developed when the seedling was planted two opposite, linear, lanceolate leaves, followed by seven leaves of the same shape arranged spirally. On subsequent growth in the house trifoliate and difoliate leaves only were developed, but the growth of this branch was soon stopped through being shaded by the others.

On the branch 27 cm. long there were, to start with, two opposite linear leaves at the base, followed by five linear leaves in a spiral, and then six trifoliate leaves, with very short internodes, also in a spiral, the branch being only 1 cm. long. On being brought into the house it commenced by producing twelve trifoliate leaves, with gradually increasing internodes; then fifty linear, lanceolate leaves, gradually becoming narrower towards the tip, but none of them developing any stiffness or any pronounced spine. In the axils of the three lowest trifoliate leaves no branches were developed. In the axils of the next three leaves primary branches were developed which did not terminate in spines, but in a bud. In the axils of the other trifoliate leaves and the linear leaves, rudimentary spiny branches were produced, without, however, any very pronounced spinescent character. The four remaining primary spiny branches presented the same modifica-

tions, with only slight differences of detail. It is to be noted that the branches just described are not accessory branches, but primary spiny branches, which very rarely, in ordinary cases, reach such dimensions as 27 or 30 cm. of length. In a seedling which had obtained a year's start, therefore, the direct effect of the altered environment was to produce a reduction of stiffness and spines, and an increase in the number of functional leaves. The same effect was visible upon the accessory branches developed on other parts of the seedling.

It will be remembered that primary spiny branches were developed in the axils of all the linear, lanceolate leaves of the original seedling, and in each case an accessory bud was formed between the spiny branch and the leaf in whose axil it was produced. Five of these accessory branches reached a length of 2, 3, 4, 6, and 7·5 cm. respectively. The two longest were developed near the apex of the seedling, the terminal bud of which had apparently been killed by the previous cold winter, as it did not continue its growth. These branches bore linear, lanceolate leaves, in the axils of a few only of which were developed very rudimentary spiny branches. No trifoliate leaves were developed, but in all other respects they resembled the branches already described.

This seems conclusive as to the effects of the environment in reducing the normal character of the Furze bush, reduction of spiny branches, and larger development of leaf surface in proportion ; but in order to test it still further, I took a seedling which had already had two years' start, having stood the very hard winter of 1894—5, and brought it into the house, where it was exposed to a uniform temperature, and supplied with plenty of water. The main axis of this seedling above ground was 3 cm. long, the terminal bud having been killed probably by the hard winter of 1894. Seven lateral branches were developed on the axis, which reached lengths respectively of 7, 3, 6, 3, 6, 7·5, and 5·5 cm. They were developed in the axils of trifoliate leaves. All these branches developed linear, lanceolate leaves, with well developed spiny branches in their axils ; and in the 5 larger branches each axil developed an accessory bud. Of these accessory buds, four to six developed on each branch to lengths of from 1·5 to 16 cm., seven of them being more than 7 cm. in length ;

the other accessory branches were very short, or remained undeveloped. Each of these branches repeated the same modifications as regards reduction of the spiny nature and sturdiness that we have already considered.

I think we may safely consider therefore that the environment has a considerable effect upon the spine-producing nature of the Furze plant and that it is largely reduced by a plentiful supply of moisture. The production of spines however has been explained as a protection against animals, and whether drought has caused this directly or not, there is no doubt that, in the majority of cases, the spinescent character is of great value to the plant against the attacks of animals. That there is a necessity for the Furze to be protected in this way is seen in the fact that, even in its present condition, if properly prepared so as to destroy the spines, it serves animals as food, In the article "Agriculture" in the *Encyclopædia Britannica.* for example, we find that the young shoots of Furze are palatable and nutritious as food for cattle and horses. It must be chopped and bruised to destroy the spines. This is done now by a variety of machines; formerly by beating it upon a block of wood with a mallet. It yields valuable food in poor dry soils (it also increases the amount of Nitrogenous matter in the soil, as do other leguminous plants, by means of the tubercles on its roots). Cows fed upon it give much rich milk free from any unpleasant flavour. It may be sown and treated as an ordinary green crop, and a succession of cuttings may be obtained from the same field for several years. Professor Muir also, in his work on "Agriculture," states that stock like it very much when crushed and chopped, and it is particularly useful because it is ready for consumption in the winter when green food is usually scarce.

Mr. Henslow, in his book, *The Origin of Plant Structures*, seems to take it that the development of the spiny character is due entirely to drought, and does not admit that selection due to animals has had any part in it. The two great factors, according to him, are the tendency to variability and the environment. But, even could one admit that the reduction in the leaves is due directly to drought without the intervention of natural selection, spines could not be explained in that way. Spines, as such, do

not protect plants against drought, neither can we regard their production in their present perfect form as a mere accident due to the larger development of the woody character of a plant. It seems to me that, at present at any rate, the only explanation of spines is that they are a protection against animals; and this has been brought about by natural selection, those seedlings which survived being just those best able to protect themselves from animals. In other words, the reduction of the succulent tissues, the hardening of the mechanical elements, and a consequent tendency to spininess, although due primarily to variability and environment, have been gradually perfected and made permanent by natural selection. It is quite true, nevertheless, that a favourable environment tends to reduce the spiny character of a plant; but it would probably take many years of very careful artificial selection before the Furze plant could be brought back again to the ancestral form possessing only trifoliate and non-spinescent leaves.

The development of the Furze seedling offers many interesting features. The seed germinates in the normal way by sending down a primary tap-root, first of all, into the soil, and a plumule with two fleshy cotyledons upwards into the air. The cotyledons are forced through the soil by the arching of the hypocotyl (Figs. 1 to 7). They are thick and fleshy, white or light green in colour on the under surface, dark green above, oval in shape, and with no hairs. In a normal seedling the cotyledons are succeeded by one or two pairs of trifoliate leaves, covered with hairs (Figs. 7 and 8). These are generally curved upwards at the margins, and thus grooved or concave on the upper surface. They are thick and shiny and of a dark green colour. The trifoliate leaves are succeeded by several pairs of spathulate leaves, broader at the top than at the base; they are both described by Lubbock as petiolate. The arrangement of these first leaves varies. They may be alternate and spiral, but are usually opposite to each other and in pairs. The spathulate leaves are succeeded by leaves which gradually become less and less broad at the apex, until finally we get a narrow-pointed leaf tapering from the base upwards (Fig. 10). At the same time, a spine, which is already present in a rudimentary condition in the trifoliate leaf, becomes more and more deve-

loped until it forms a disagreeable puncturing instrument at the tip of each leaf.

In some seedlings this normal course of leaf development is not followed; in fact, a very great variety in the number and arrangement of the leaves is found. The following are a few examples of seedlings, collected on Woodhouse Ridge, Leeds, which will show how largely they vary:—

No. 1.—Seedling germinated in autumn, 10 cm. long; collected in April after a mild, damp winter. Had grown in stony loam.

1st to 5th—Trifoliate leaves.

6th—Difoliate leaf, with small lateral leaflet.

7th—Trifoliate leaf.

8th—Spathulate leaf.

9th to 13th—Linear leaves with spines.

There were spines in the axils of all these leaves; and in all, except three of the trifoliate ones at the base, there were accessory buds between the leaves and the spines.

No. 2.—A seedling grown under the same conditions as No. 1, but 7·5 cm. long.

1st to 4th—Leaves in pairs, opposite, spathulate, and the other leaves were spirally arranged.

5th—Difoliate leaf, with a small lateral leaflet.

6th—Spathulate leaf.

7th—Spathulate, with a very small lateral tooth.

8th—Spathulate leaf.

9th and 10th—Spathulate leaves, but narrower; prickle at top becoming more pronounced.

11th and 12th—Slightly spathulate, with stronger spines.

13th and 14th—Leaves tapering from base upwards and terminating in strong spines.

All these leaves, except one or two lower ones, had spines in their axils, but no accessory buds could be seen.

No. 3.—A seedling, 2·5 cm. long, germinated in the autumn; collected in April. Had been growing in humus soil, well exposed to light.

1st—Two leaves opposite, paired, trifoliate; subsequent leaves not in pairs, spirally arranged, but with very short internodes.

3rd—Leaf with one lateral leaflet.

4th—Spathulate.

5th to 9th—Trifoliate.

10th—Difoliate leaf, with small lateral leaflet.

11th to 17th—Trifoliate leaves.

18th to 20th—Difoliate.

21st—Spathulate.

22nd to 29th—Slightly spathulate.

There were no spiny branches in the axils of any of these leaves.

No. 4.—Seedling, 4·0 cm. long, grown under same conditions as No. 1, and in same soil.

1st—Two leaves opposite: one difoliate, the other spathulate.

3rd and 4th—Spathulate, nearly opposite, but not quite on same level.

5th and 6th—Trifoliate, nearly opposite, not quite on same level. Subsequent leaves arranged spirally.

7th to 9th—Trifoliate.

10th to 30th—Linear, gradually becoming normal, and terminating in spines.

Spiny axils were developed in the axils of all the leaves after the 7th.

No. 5.—Seedling grown under the same conditions as No. 4, 6·5 cm. long.

1st pair of leaves, opposite, trifoliate.

2nd pair, not quite opposite, trifoliate.

3rd to 9th—Trifoliate.

10th to 12th—Spathulate.

13th—Difoliate.

14th and 15th—Trifoliate.

16th—Difoliate.

17th to 32nd—Spathulate, gradually passing into the linear form, with well developed spines.

In the axils of all the leaves after the 5th were spiny branches.

No. 6.—Seedling, 1·5 cm. long, growing in humus soil, germinated in autumn and collected in March of following year. Had twenty leaves, all trifoliate.

No. 7.—Grown under same conditions as No. 6. Had thirty leaves, all trifoliate.

Seedlings were also observed of the second year's growth, growing under the same conditions, with more than one hundred trifoliate and difoliate leaves.

These observations are not only interesting as showing the very considerable variation existing among seedlings of *Ulex*, but, as I have already mentioned, afford some evidence of the effect of the environment upon the production of the spiny character; those seedlings which were grown upon humus soil having begun to develop the spiny character much later than those grown upon the stony loam.

The primary axis of a seedling stops growing, according to Buchenau, at the end of the first year. In all the seedlings which he examined at this stage, he found that the tips were dead, and the same thing was repeated on the side-shoots. He supposes that the young buds at the apex get killed by the frost. My own observations show that this is not so, however. In many seedlings I have found that both the main axis and the lateral shoots continue to grow a second year, but very rarely for a third year. It is probable, however, that it is only during a fairly mild winter—such as that of 1895-6—that any considerable number of apical buds escape destruction.

The trilobed form of the primary leaves in seedlings of *Ulex* is compared by Buchenau to that observed in seedlings of *Cytisus*; and Winkler also has a paper on the comparison of the two seedlings. According to these observers—and, generally, my own observations agree with theirs—the seedlings of *Cytisus* develop four- to six-stalked trifoliate leaves, the first few pairs being in pairs and opposite to each other, and the others arranged spirally. But, just as in *Ulex*, this development varies. Spathulate leaves are sometimes first developed, then trifoliate ones, and these again may suddenly or gradually pass over into the spathulate form. There is no reduction of the leaves to spines. It is interesting, also, to compare the adult plant of *Cytisus* with that of *Ulex*. In the former the lower leaves on a branch are stalked and trifoliate; the upper ones are sessile and often reduced to a single leaflet. The simple leaves are produced, as in *Ulex*, by the loss of, first, one lateral leaflet, then the other. *Ulex* differs from *Cytisus* only in the fact that trifoliate leaves are formed much less frequently,

and only on the branches of young plants as a rule, but they are developed in the same position, at the base of the branch. We have, in fact, the same kind of modification in both plants, the stems being ridged, and the leaf surface reduced by a gradual modification of a trifoliate to a simple form, and this has gone some steps further in *Ulex* than in *Cytisus* by the further reduction of the simple leaves to spines. This all points to a common ancestry for the two plants, and their development from a form in which all the leaves were trifoliate, as occurs at the present day in closely allied species, such as the common Laburnum of our gardens, in which all the leaves are trifoliate from the beginning.

The formation of a number of trifoliate leaves on the seedlings and young branches of *Ulex* is probably, then, a survival of the ancestral structure, and when a large number are produced we may regard it as a reversion to the ancestral condition brought about by the favourable conditions of the environment. The development of trifoliate leaves may, indeed, be favoured by many circumstances.

Thus, exposure to light favours the production of leaves with a larger surface, and this in the case of *Ulex*, owing to the ancestral tendency, is brought about more readily by the formation of trifoliate leaves than by an increase in the size of the simple leaf. At the same time, the stem is reduced in length and the leaves appear near together at its apex in the form of a rosette, as occurs in many plants grown in exposed situations. This increase in the size of the leaves by exposure to light takes place only to a certain extent, however; drought tends to reduce them, so that we should expect to find trifoliate seedlings more abundant in places exposed to light, and with sufficient supply of moisture than in those places where one condition is present without the other. Again, it is probable that the reduction of the leaf-surface is in part brought about by cold, which prevents the due absorption of water by the roots, and consequent necessity for economy of the supply already obtained. And as humus soils are warmer than loamy soils, we should expect to find, what is actually the case, that trifoliate seedlings are more abundant on the former than on the latter.

We may sum up the various causes which appear to have a tendency to modify the seedlings of the Furze plant as follows :—

The reduction of leaf-surface and production of spines is favoured by :—Drought ; shade of other plants ; cold winds and soils ; hereditary tendency to production of spines (due to animal selection).

Increase in the leaf-surface and production of trifoliate leaves is favoured by :—Moisture ; exposure to light ; warmth ; ancestral tendency to produce trifoliate leaves.

In the adult plant the conditions under which they are grown may tend to modify the earlier leaves developed on the lateral branches ; but those formed later, whatever may be the conditions, always develop the spiny character.

It is interesting to note that seedlings intermediate between those which possess a large number of trifoliate leaves and those which have linear leaves only, are constantly found in which the struggle between those conditions which tend to produce trifoliate leaves, and those which tend to form only linear leaves, is seen in the fact that they show all sorts of stages in the reduction of trifoliate leaves to simple ones, with very few of the former, and never quite reaching the latter. One such seedling, collected in the shade, had the long internodes, characteristic of seedlings with linear leaves ; but the lower thirty leaves were neither trifoliate nor simple, but were in all stages of transformation of the former into the latter. Such cases are not uncommon, though it is rare to find such a striking example.

We have already seen that all the young leaves and leaflets on a seedling are curved upwards at the margin to form a furrow extending down the middle of each leaf to the stem, or, in the case of the lateral leaflets of a trifoliate leaf, to the median furrow of the leaf. They are also curved downwards in a very decided manner, becoming in many cases parallel to the stem. It appears exactly as if this were an arrangement by which water is enabled to run off the plant and prevent it getting wet. On trying some experiments, however, to test this, by pouring water on to a seedling from a height, it was found that very little water indeed escaped this way, and that it was nearly all conducted, by means of the furrows on the leaves, to the stem, and then delivered in a

stream down the roots. Many experiments were tried; seedlings of different sizes were taken, but all with the same result. It may be useful to give a few details of one or two of the experiments.

Experiments with a seedling 1 inch high, with trifoliate leaves:

1.—Water was poured from a spoon, or allowed to run out of a pipette, at a height of 4 to 6 inches. None of it dropped from the tips of the leaves. It was all conducted to the root.

2.—Water poured in same manner on the leaves at one side of the plant. About ⅓rd of it fell off in the form of drops, the remainder was taken down to the root.

3.—Allowed water from watering pot to fall from a height of about 2 feet on to the plant. Nearly all the water which fell on the plant went to the root.

The leaves become easily wetted, but when quite dry the first few drops fall off the leaves quite easily. The same experiments were tried with a seedling three inches high, having trifoliate leaves at the base and linear leaves at the top, with the same results. It was noticed in this case that if, by any chance, a drop of water fell off any of the upper leaves, it was caught by the lower ones. and by them conducted to the root. A seedling two inches long, with linear leaves, allowed very little water to escape any other way than by the roots. On allowing water to play on a plant with ten branches from five to eight inches long, from a watering pot, most of that which fell on the plant was conducted down the stem and delivered in a large stream at the roots; very little escaped in any other way.

The following experiment was tried to show how easily and rapidly the plant conducts water to the root even when applled under great pressure:—A seedling two and a half inches long was taken with linear leaves, the diameter of the seedling about ¾ of an inch in its widest part, A pipette with an indiarubber cap was taken, filled with water, and brought to the apex of the seedling, so that the opening was placed near the centre of the young leaves. The indiarubber cap was then pressed suddenly and strongly, and the water expelled, but none escaped laterally; it was all delivered at the roots. On sending water in laterally the same result was obtained.

The leaves seem to take up the water and conduct it to the

stem by means of the capillarity of the furrow on the upper surface. A drop of water placed on the tip of a leaf, which was curved downwards, did not fall off, but was immediately taken away up the furrow to the stem. It was even found that on dipping the apex of a leaf in water that it was slowly conducted away and delivered in drops at the root.

These experiments seem to show the seedling—growing, as it often does, upon stony and sandy soils—is enabled, by means of the collecting power of its leaves, to ensure that its roots shall have a chance of absorbing whatever water may fall upon it, and so to some extent overcome the difficulty of the water supply in a soil from which water is so quickly drained.

In conclusion, we shall see, I think, that this study of the Furze plant, incomplete as it is, affords an insight into the contrivances by which Nature is able to overcome the difficulties of various kinds to which plants are subject during their development, and shows how quickly they may respond to changes in the environment, and so produce variations ready, if necessary, to be further improved and strengthened by natural selection.

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EXPLANATION OF PLATES IV. AND V.

Fig. 1.—Seed of *Ulex Europæus; n*, hilum.

,, 2.—Seed beginning to germinate; shows where the root will emerge.

,, 3 to 6.—Further stages in the germination of the seed of *U. Europæus*. *ct.*, Cotyledons; *s.*, Growing point.

,, 7 and 8.—Young seedlings of *U. Europæus*, showing trifoliate leaves.

,, 9.—Seedling of *U. nanus*, var. *Gallii*, with two trifoliate leaves and a number of linear leaves, showing how these are arranged to expose the largest leaf-surface to light.

,, 10.—Copies of nature-printed figures, showing the process of modification from the trifoliate to the spiny form of the leaf of *U. Europæus*.

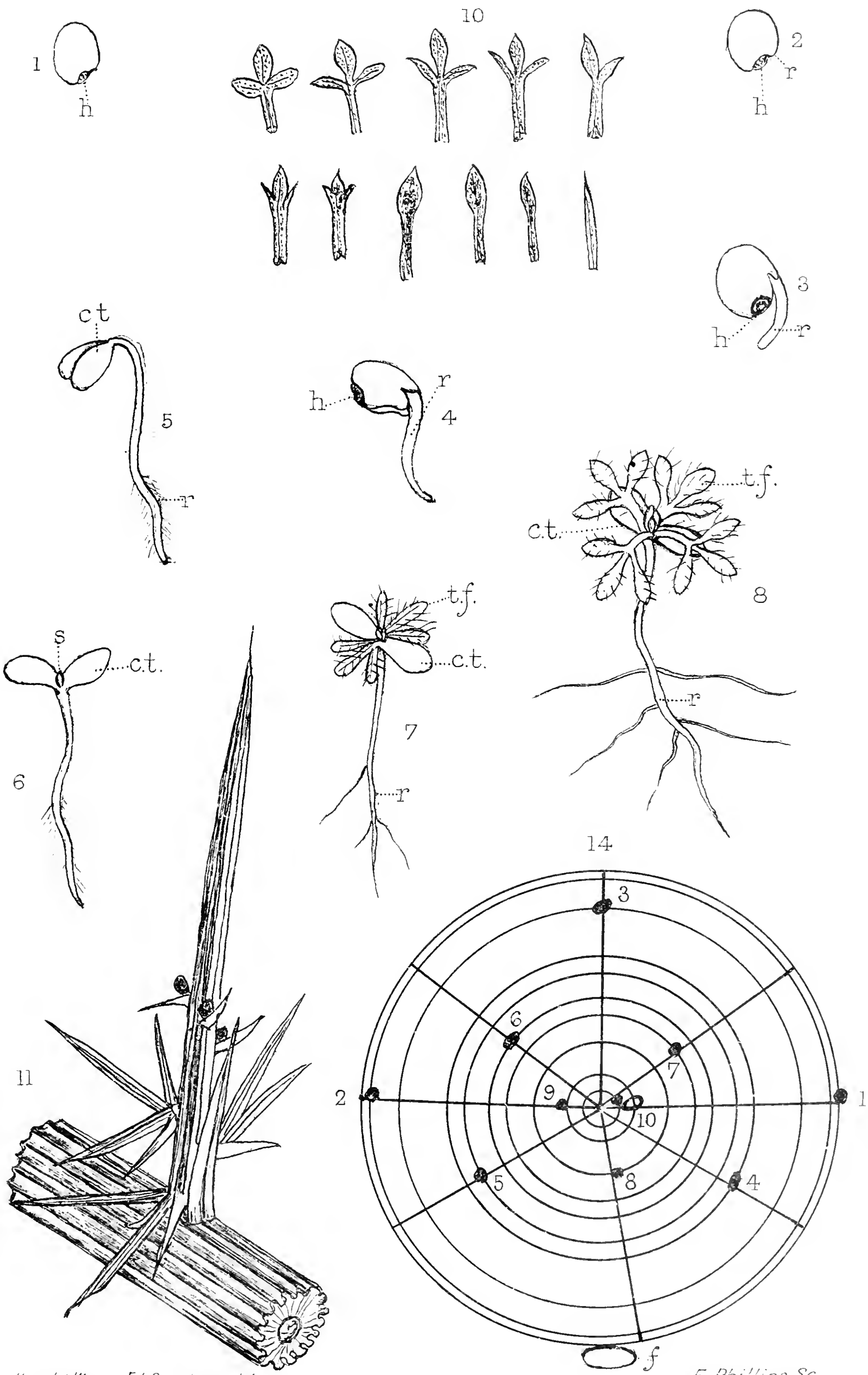
,, 11.—Small portion of a branch of *U. Europæus*, showing a primary spiny branch in the axil of a foliage leaf. Between the foliage leaf and the thorny branch a minute accessory bud was found. The three upper foliage leaves on the thorny branch bear flowers in their axils. Slightly magnified.

,, 12.—Transverse section of a spiny branch, diagrammatic. *v.b.*, Vascular bundles; *en.*, endodermis; *s.*, strengthening tissue; *a.*, assimilative tissue; *e.*, epidermis; *st.*, stomata; *c.*, large thin-walled cells, just inside the assimilative tissue.

,, 13.—Portion of transverse section of a primary spiny branch, highly magnified; lettering same as in Fig. 12, and in addition, *p.*, phloem; *cb.*, cambium; *xy.*, xylem; *h.*, hairs; and *pc.*, pericycle.

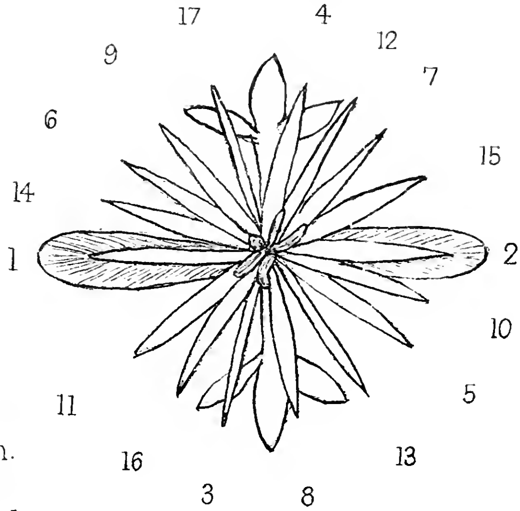
,, 14.—Figure showing the arrangement of the leaves on a primary spiny branch. *f.*, Foliage leaf of the branch on which the thorn is borne. The distances between the circles indicate the length of the internodes between the leaves.

Revival of an Old Histological Method for Rapid Diagnosis.—Dr. A. A. Kanthack and Mr. T. S. Pigg had found, of all rapid methods of hardening tissue, that of immersing small blocks in boiling water for three or four minutes, or in the case of delicate tissue one minute, the most rapid. The tissue could then be at once cut on the freezing microtome, and the section stained well with logwood or other dyes; or it could be preserved in alcohol or Müller's fluid, or treated by the paraffin method. For rapid diagnosis in the case of surgical operations, it was particularly valuable.—*British Medical Journal.*



Harold Wager F.L.S. ad nat. del.

F. Phillips Sc.



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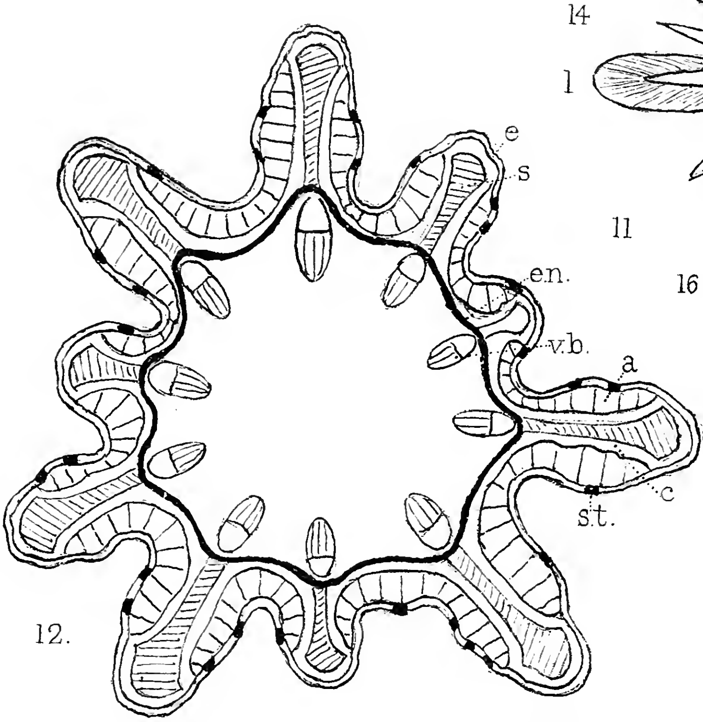

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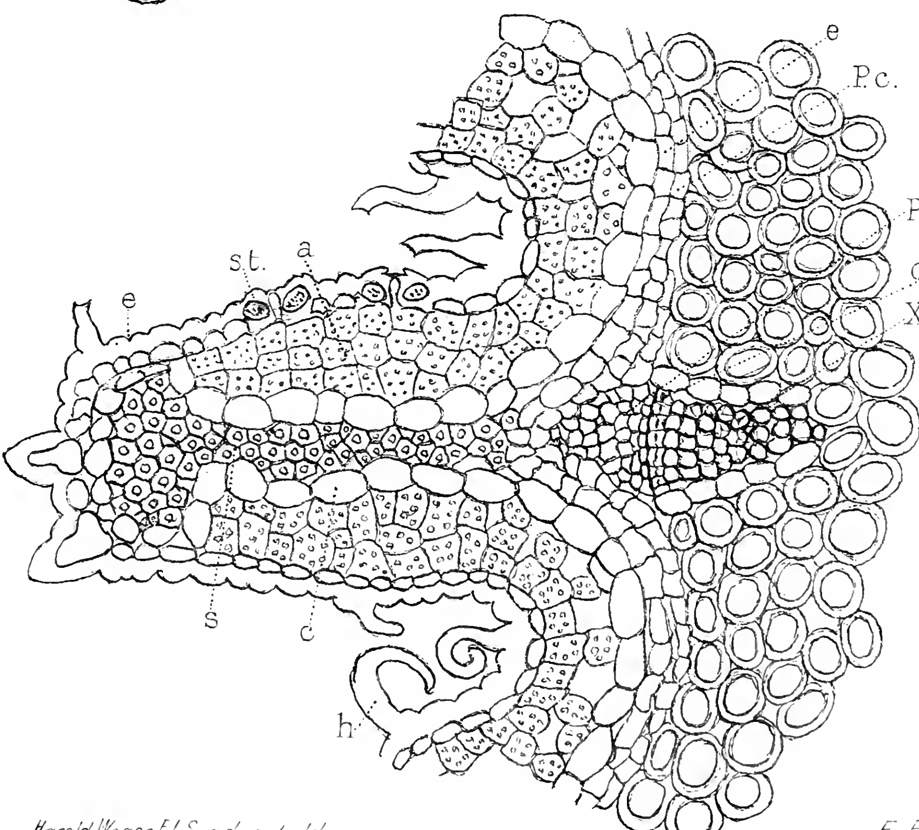

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Harold Wager F.L.S. ad nat. del.

F. Phillips Sc.

Notes on Gryphæa incurva.

By John French.

THESE are the commonest fossils of the Essex Boulder Clay. They are vulgarly known under the name of "Devil's Toe-Nails," and are familiar to almost every ploughboy. Like very many others of their colleagues, they have been subjected to extensive abrasion and do not often occur as perfect fossils. The geological range of these fossils is from the Lias to the Chalk (both inclusive), but so far as I know Liassic examples do not occur in Essex. Our derivatives, I believe, are principally from the Oolitic series (Oxford clay, etc.). The abrasion, for the most part, must have long anteceded the advent of the Boulder Clay, for most of the examples, broken from their matrix of hard rock, show considerable wear. It seems to be the fate of this shell generally to appear under this aspect, even in Liassic specimens. The amount of wear and tear and tossing about can also be inferred by another standard, and that is the general absence of the right or upper valve. Perhaps I should be within the truth if I said that not one specimen in a hundred bears this appendage. I could also safely say that not one specimen in a thousand (from the Essex Drift, at least) is a perfect fossil. It has been my good fortune to meet with a few such examples, one of which was obtained from the Boulder Clay at Felstead, and is the one on which I shall venture some remarks.

In a much-hardened form, every minute ridge and marking of the original shell is preserved in this specimen. Moreover, the original had the advantage of belonging to a healthy animal, which reached maturity without misadventure and without the disadvantages attending overcrowding, and so was enabled to produce a shell as regular as the species would allow of, and as perfect as any healthy mollusk ever did.

To say that the animal "kept the even tenour of his way" would be stating a case to which probably no mollusk responds. There is sufficient evidence here of quite another state. There are main ridges in the shell corresponding to seasonal growths, and secondary ridges corresponding to minor growths. Like the

Roman builder, mollusks appear to do their masonry by small layers, allowing one to harden before the other is laid on. The secretions seem to accumulate and then to be used up in shell-making all at once. *Gryphæa*, like the oyster of to-day, was great in this matter of shell accumulation—perhaps too great, as it may appear.

A peculiarity is manifest in *Gryphæa incurva*, which, so far as I know, has no match in other members of the oyster family. This is the circumstance that the adult animal probably could not be contained in the shell when the valves were closed, This would appear, however, only to apply to the adult form, in which the lower valve, being much thickened on the inside, becomes very shallow, for in immature form the shell is much deeper in proportion and allows plenty of room. In my specimen, which is perfectly adult, the lower valve is slightly recurved at the lip, which I think clearly proves that the animal at that stage somewhat overhung its shell. This, however, does not entitle us to say that the upper valve had become rudimentary, although the tendency was certainly in that direction, for, as we have seen, the upper valve formed a real protection during a great part of the animal's life. Moreover, the adductor muscle, being well developed, shews that it was in frequent use.

In considering to what part of the line of ostreal development this organism should be referred, the two valves of the shell would seem to furnish an answer. The elaboration and tremendous development of the lower valve shows that the shell-bearing functions were at or about at the maximum, and were nowise in a nascent condition. The smallness of the upper valve is probably to be explained by the same circumstance that gave such an unequal impetus to the growth of part of the lower valve, to be presently noted, and at the same time gave such an undue preponderance of shelly matter to that section.

These considerations, coupled with the tendency to abort an important organ (see above paragraph), seem to stamp the form as specialized and therefore later, and not ancestral or earlier. This view will receive further support in considering the development of the lower valve.

There is no clue given by the study of the immature shell of

G. incurva, as to how and when the departure from a primitive form took place, or any hint as to the nature of that form. The smallest shells procurable, which are probably those of the first year, show all the characteristics equally of the adult form. We can, therefore, only say that, although its first appearance is in the Lias formation, its development took place probably long anterior to the laying down of that deposit.

The peculiarity in the development of the lower valve is very interesting. The adductor muscle was always attached to one side of the shell, technically known as the dorsal side. This leads us to suppose that side to have been the primitive one, and the other side, or lobe, which is marked off by a furrow on the exterior, to have been a subsequent development. This subsequent development is that which gives to the shell its generic characteristics. It forms the bulk of the lower valve or umbone, and in the course of its development pushes the apex towards the dorsal side. Meanwhile, the growth of that side proceeds much more slowly, and always holds a small relative proportion. It is, perhaps, due to this great demand that the upper valve appears to be so much impoverished. This valve is of very variable proportions as regards thickness. Assuming that it receives its increments in due course, the quantity of shell deposit must be variable in different individuals, if not at different times in the same individual. This variability, if it occurs in the lower valve, is not so easily detected in the sum of its results.

The lateral position of the adductor gives rise to a conjecture as to whether that position may not have something to do with checking the growth of that particular side. Being large in proportion to the surface of that lobe, and in its course traversing about three-fourths of the length of the shell, it must apparently always be detrimental to its growth. In this case the unsymmetrical development of the shell may be due to the same cause that shifted the adductor from its central position. This, however, has no connection with the otherwise excessive development of the lower valve. This seems to be bound up with the cause which has given us other large developments in the oyster family in geological time, and which at the present time produces in the same

species large-shelled varieties along with those in which the growth of the shell is much checked.

Gryphæa, unlike the present oyster, passed its life in an unattached position, stability in that form being procurable in a different manner. The tendency of the growth of the great ventral lobe and umbone was to turn over the shell on to its side. This, however, was prevented by the growth of the dorsal lobe, so much so that the shell was kept constantly stable at an angle of about 45°, and would allow of rather a large angle in which to rock should it be required. The advantages of this position, in which the animal was well removed from the mud or sand, is very obvious.

Unlike the present oyster, also, in the matter of foreign growths, *Gryphæa incurva* was a pattern. Nothing appears to have been allowed to attach itself to the shell. In upwards of fifty specimens examined, I could only trace the work of even a sponge in three cases, and in all of these the marks had been quickly healed over. This leads us to suppose that the animal was possessed of an epidermal pellicle, chemically adjusted to prevent the adhesion of other organisms.

This mollusk, though variable within certain limits, remained practically unchanged for a very long period of time (Lias to Chalk at least), and how it became finally extinct we do not know. Like the oyster of to-day, it probably had many enemies, but whether it succumbed to any of them we do not know. If, in the great space of time following the Chalk, which to us is a hiatus in organic life, the upper valve became really rudimentary, it would seem by that change to have placed itself to a distinct disadvantage. But when we remember that the close-fitting valves of the present oyster are but little protection against its most mortal enemies, we can feel no assurance in pursuing that line further.

So far as we are able to judge, the changes which took place in the evolution of *G. incurva* are not to be expressed in terms of usefulness to the animal. The ingenious means by which stability was attained without resulting to attachment was satisfactory so long as nothing occurred to violently disturb its equilibrium; but in the event of an accident occurring sufficient to throw the shell upon its other side, the consequences were disastrous. Then the

weight of the heavy umbone, which before had been its safety, became its ruin, for it was quite impossible for the animal to right itself again, and in that prone position sand or mud was a constant occupant and must have caused disease and death. Again, as we have seen, the protection of the upper valve was removed in proportion as the specialisation of the shell proceeded. That course can only be regarded as suicidal, to a degree at any rate.

There is much variation in the comparative breadth of different shells of *G. incurva*, but whether this was correlated to other shell variations—as that of the thickness of the upper valve—or whether it was hereditary, we have no means of judging.

The modern oyster has a great faculty for adapting its shell to surrounding circumstances, but the shell of *Gryphæa* is rarely, if ever, deformed. Had the organism been endowed with locomotive powers, this would have been of easy explanation; but in the absence of those powers, it seems only open to suppose that it did not frequent crowded situations, or, in other words, was approximately or in reality a deep-sea inhabitant. Its duration of life was probably about the same as the present oyster.

P.S.—It has been objected to the above that I "assume the atrophy of the upper valve," a position which my critic thinks an "impossibility . . in bivalves." The objection may, I think, be allowed to stand without materially affecting the observations which it was the intention of the paper to put upon record.

I should like, however, to say a few words, based rather upon observation than upon anatomical knowledge, of this "impossibility."

The operculum of Gasteropods is, I believe, still supposed by good authorities to be the homologue of the upper valve of Lamellibranchs, and as many Gasteropods have lost it altogether it is clear that in the same number of cases it has at some time commenced to suffer atrophy. If one mollusk can, therefore, abort a part of its shell, there surely can be nothing impossible in a similar allied organism performing the same operation. The like argument may be applied in greater or less degree to very many species in which the shell has more or less become rudimentary, the naked slugs being the most pronounced examples.

The modern oyster, under a highly cultivated form, seems to

present an example of incipient atrophy of the upper valve. I refer to the variety known as "Burnham Natives." An oyster merchant once told me that the feeding on his "layings" tended to thin out this appendage at the edge, and in proportion as this thinning-out or paring-off was apparent the animal was considered "true."

The Cucumber and Tomato Eelworm.*

By W. Dyke. Plate VI.

THERE is a division in the animal kingdom known to the zoologist as vermes (worms). This division comprises a number of diverse groups, one of which is known by the name of *nematoidea* (Gr., *nema*, thread; *eidos*, form). The nematodes are, therefore, threadworms, of which more than a thousand species are known.

During the last few years many cucumber and tomato growers in this country have lost a considerable number of their plants annually owing to the formation of nodular enlargements (root galls) upon the roots. For some time the cause of these nodular formations was a mystery to growers, and not until Miss Ormerod issued a report upon the subject (*Report of Observations of Injurious Insects, etc.*, 1892, pp. 127—137) did it become generally known that the formation of galls on the roots of Tomatoes, Cucumbers, and a few other plants growing under glass was the work of a nematode worm called by Müller *Heterodera radicicola.*

The destructiveness of this pest is so great as to often cause the grower to lose from 50 to 75 per cent. of the above-named plants, and, therefore, one cannot wonder that they dread its introduction into their establishments.

Cucumber plants fall a more easy prey than Tomatoes to an attack of Root eelworm. This is no doubt owing to the soft nature of the tissues of the first-named plants, for I have seen in several instances Tomato plants growing and fruiting fairly well in houses so infested as to make it impossible to grow Cucumbers.

* From *The Journal of Horticulture.*

The roots of plants when infested with Root eelworm present an irregular, knotty, or warty appearance, and are often from two to ten times larger in diameter than ordinary roots. These nodular enlargements or root galls when first formed are smooth and light in colour, but at a later date the surface roughens and cracks, and is then dark brown, owing to the root gall having commenced to decay.

If we take one of these brown decaying galls and pull it carefully apart, we may probably see with the naked eye small white oval bodies lying in the darkened decaying tissues. These more or less oval bodies are the matured female cysts (Pl. VI., Fig. 1), being from one-fiftieth to one-hundredth of an inch in diameter. They are pointed at the head end, and under the microscope the cyst or chamber looks like an inflated bladder, or what Professor Atkinson calls "a crooked-necked squash."

In the head end we find a mouth (Fig. 1, *a*), provided with a hollow exsertile spear (Fig. 2). This spear is found in both sexes, and can be extended with considerable force, its use being (1) to batter in the cell-walls of the plant, either to enter or exit; and (2) to form a passage by which the food may be drawn into the stomach of the worm. The food passage looks, when viewed under the microscope, like a dark line running down the centre of the spear, which terminates in an egg-shaped muscular gizzard or stomach (Fig. 1, *b*), the latter being attached to the alimentary canal.

If we look carefully at one of these female cysts under the microscope, we may be able to see lying in its interior two long coiled cylindrical objects having free ends (Fig. 1). These are the genital tubes, and in a fully developed cyst will be found to be packed with eggs in all stages of development. The eggs are developed in immense numbers in the ovaries (Fig. 1, *c*), and as they increase in size they pass along the oviduct (Fig. 1, *d*), and are finally expelled from the vulva (Fig. 1, *e*). When the eggs are expelled they are cylindrical in shape, but they soon change in form, ultimately becoming bean-shaped (Fig. 3). The eggs are from three to four-thousandth part of an inch in diameter.

The eggs are filled with protoplasm, in which may be found a nucleus (Fig. 3, *n*). The early process of development of the egg

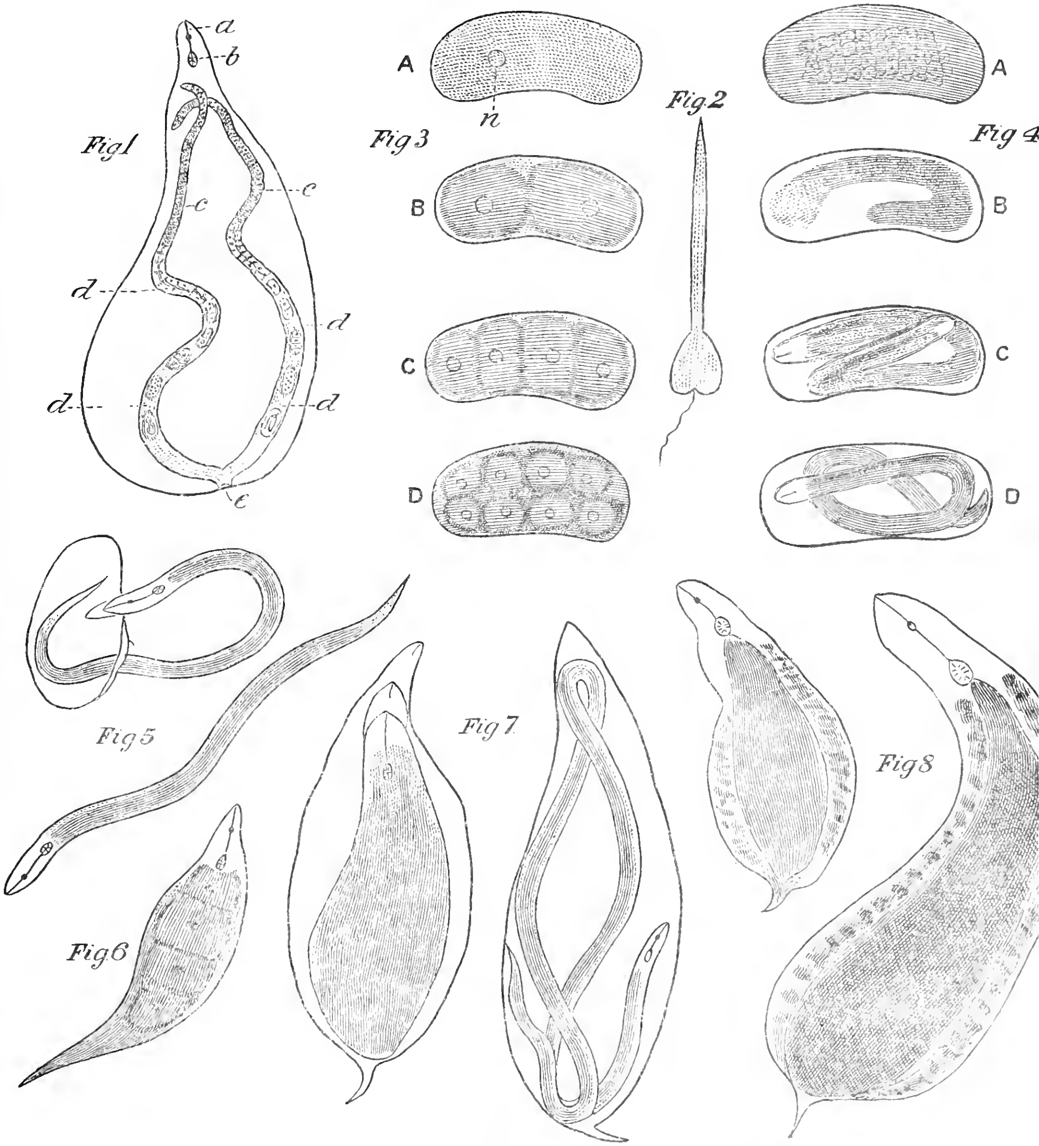
into an embryonic worm is similar to that of a living cell in the growing part of a plant—*i.e.*, the nucleus and protoplasmic contents divide, a cell-wall is formed in the division, so that the mother cell or egg (Fig. 3, *a*) now contains two daughter cells (Fig. 3, *b*). By similar divisions these daughter cells again divide (Fig. 3, *c*, *d*), until a mass of cellular tissue is formed (Fig. 4, *a*), from which the young embryonic eelworm is ultimately developed (Fig. 4, *b*, *c*, *d*). The embryo remains for about two days in the egg and then comes out (Fig. 5).

The young wormlet is about the twelve-thousandth part of an inch in diameter, and is thread-like in shape, tapering gradually to a blunt head-end, and gently into a slender needle-like tail. This is known as the *larval stage.* During the larval stage males and females are both alike in appearance—*i.e.*, eel-shaped, and are easily mistaken for *Tylenchus devastatrix* (the stem eelworm).

When the eelworm leaves the egg, it generally finds itself imprisoned within one of the cells of the plant. As soon as the supply of food in the cell is exhausted, the worm has either to pass out of the cell or die of starvation. It can, however, pass from cell to cell by battering in the cell-wall, which it does by means of the spear.

Sometimes hundreds of worms are liberated by the decay of the root gall; these find a fresh portion of root, and enter it by piercing through the cell-walls. The plant is not able to expel the intruder, but it tries to repair the injury by the development of fresh cells; hence the formation of the nodules or galls on the roots. After a time the young worms come to rest, and their bodies begin to enlarge, the posterior end becoming larger than the anterior portion (Fig. 6). The male, which up till now has been similar in appearance to the female, undergoes various changes and modifications, ultimately assuming the eelshape again (Fig. 7), while the female undergoes a transformation which differs in every respect from the male. The female, instead of returning to the eel shape, continues to enlarge (Fig. 8), its tail is cast off, and its reproductive organs are developed. The male, after wandering about for a time in the tissues of the plant or in the soil, finds its mate and pairs, then dies.

The eggs begin to be developed while the female cyst is com-



HETERODERA RADICICOLA (*highly magnified*).

Fig. 1, Female cyst:—(*a*) mouth, (*b*) stomach, (*c*) ovaries, (*d*) oviducts, (*e*) vulva. Fig. 2, Exserti spear. Fig. 3, Eggs in various stages of development; (*n*) nucleus. Fig. 4, Development of embry Fig. 5, Worm (larval stage) emerging from egg: Fig. 6, Commencement of change from larval to cyst stage. Fig. 7, More advanced development of male. Fig. 8, Female from larval to cystic stage.

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paratively small, but it has not yet been determined when fertilisation takes place. However, it must occur long before the female cysts are fully grown. On an average each female cyst produces something like two hundred eggs. It takes about one month for the eggs to develop into full-grown males or pregnant females. The following will, therefore, give us some idea to what extent this pest can multiply, for let us suppose that one female cyst produces 200 eggs, allowing one half of these to be males, in one month there would be 10,000 female worms, in two months 1,000,000, in three months 100,000,000, and so on. These figures must not be taken as what does occur, but are only for the purpose of illustration. A great deal more might be written on the life-history of this pest, but I think the above is sufficient to give those who are troubled with it some idea of what they have to deal with.

For remedies I would refer the reader to a discussion now going on in the *Journal of Horticulture*, but from the brief description I have given it is easy to see that we can only hope to eradicate the pest by taking radical measures as soon as it makes its appearance. When once established, it is, as far as my experience goes, impossible to get rid of it. In conclusion, I have to thank Mr. F. S. Hutchason, Wormley, Herts, for the use of the diagrams, which, I may say, were taken from living specimens we examined under the microscope.

[Miss Ormerod has done splendid work in many other ways than in giving the first account in this country of the life-history of *Heterodera radicicola*, from information largely supplied by Dr. J. Ritzema Bos, Prof. Atkinson, and Dr. J. C. Neal; but so far as we know the world is indebted to the late Rev. M. J. Berkeley for its discovery. Cucumber root galls, also a cyst female with eggs and young larvæ, were figured by him in the *Gardeners' Chronicle* in April, 1855. Mr. W. G. Smith gave an excellent illustration of eelworms in Cucumber roots in the *Journal of Horticulture*, Jan. 14th, 1875, taken from the most gigantic example of Cucumber root clubbing we have ever seen. Mr. Smith was well acquainted with Mr. Berkeley's female *Heterodera*. which was at first taken for a large vegetable cell in which the eggs were encysted. Professor Percival has closely investigated the subject, and is as

familiar with eelworms as gardeners are with slugs. Mr. G. Abbey has also been a diligent investigator, knows the pest well, and has meritoriously striven to conquer it. Mr. Hutchason and Mr. W. Dyke have done good service in making clear to our readers the life-history of the scourge, by delineations from original specimens as represented in the accompanying plate, for the loan of which we thank the publishers of *Journal of Horticulture.*]

Energy of Living Protoplasm.

In the *Bulletin* of the Imperial University of Tokyo, Herr O. Loew gives a detailed synopsis with regard to the present state of our knowledge of the mode of formation, the structure, and the functions of the protoplasm of living cells, both in non-chlorophyllous and in chlorophyllous plants. He calculates that some microbes may give birth to a trillion of cells from a single one in the course of twenty-four hours. A great number of details are given with regard to the nutritive properties for bacteria of different organic substances. These are classified under four heads, viz. : those which are good, moderate, and bad sources of carbon. In chlorophyllus plants neither the nitrogen nor the sulphur is combined with oxygen in the albumen ; a reduction of the nitrates and sulphates must, therefore, have taken place, as in the lower fungi. Asparagin was found to be one of the most widely distributed of the intermediate substances in the production of protoplasm. As a rule, its increase in the seedling runs parallel with the decrease of carbo-hydrates. The access of air is indispensable for the formation of asparagin and of protoplasm, but not for the action of peptonising ferments.—*Pharm. Journ.*

Flatworms and Mesozoa. Nemertines. Thread-worms and Sagitta. Rotifers. Polychaet Worms. Earthworms & Leeches. Gephyrea and Phoroms. Polyzoa.*

IT is with no small degree of pleasure that we direct the attention of our readers to Vol. II., according to the classified arrangement of subjects, of this very important work. We have on former occasions had the privilege of writing notices with short extracts from Vol. III. on "MOLLUSCA AND BRACHIOPODS, and from Vol. V. on "PERIPATUS," and the first section of an exhaustive account of "INSECTS." In reviewing the volume before us, we shall, with the publisher's permission, make a few extracts, descriptive of some of the lowlier forms of Animal Life, for the twofold purpose of inducing our readers to take a more than general interest in these little-known forms, and to show how very thoroughly the various subjects have been treated by their authors, and how admirably the publishers have undertaken their share in illustrating the volume.

"The *Platyhelminthes*, or Flat Worms, form a natural assemblage of animals, the members of which, however widely they may differ in appearance, habits, or life-history, exhibit a fundamental similarity of organisation which justifies their separation from other worms, and their union into a distinct philum. Excluding the leeches (*Hirudinea*) and the long sea-worms (*Nemertinea*)—which, though formerly included, are now treated independently—the *Platyhelminthes* may be divided into three branches:—1.—*Turbellaria* (including the Planarians); 2.—*Tremadoda* (including the liver-flukes); and 3.—*Cestoda* (tape-worms).

The *Turbellaria* were so called by Ehrenberg (1831) on account of the cilia or vibratile processes with which these aquatic animals are covered, causing, by their incessant action, tiny currents ("turbellæ," disturbances) in the surrounding water.

* "THE CAMBRIDGE NATURAL HISTORY." Edited by S. F. Harmer, M.A., Fellow of King's Coll., Cambridge, Superintendent of the University Museum of Zoology; and A. E. Shipley, M.A., Fellow of Christ's Coll., Cambridge, University Lecturer on the Morphology of Invertebrates. Vol. II., pp. xii.—560. (London: Macmillan and Co. 1896.) Price 17/- nett.

Turbellaria are carnivorous, overpowering their prey by peculiar cutaneous, offensive weapons, and sucking out the contents of their victims by the "pharynx." Land Planarians feed on earthworms, molluscs, and woodlice; fresh-water Planarians on Oligochaet worms, water-snails, and water-beetles; marine forms devour Polychaet worms and molluscs.

"An account of the Polyclad *Turbellaria* may be fitly prefaced by a description of a very common representative, *Leptoplana tremellaris*, so called on account of the thin, flat body which executes, when disturbed, quivering or tremulous swimming movements. . . . Like all Polyclads, *Leptoplana* is marine. It is probably found on all European shores, northwards to Greenland and southwards to the Red Sea; while vertically it ranges from the littoral zone down to fifty fathoms. . . . . At low water, *Leptoplana* may be found buried in mud or on the under surface of stones, in pools where darkness and dampness may be ensured till the return of the tide."

The anatomy of this worm is given at great length; we shall make only sufficient extracts from the author's voluminous description to enable Plate VII., which has been kindly placed at our disposal by the publishers, to be understood.

Leptoplana may be divided into corresponding halves only by a median, vertical, longitudinal plane. The body and all the systems of organs are strictly bilaterally symmetrical. Excepting the cavities of the organs themselves, the body is solid. . . . The epidermis is composed of a single layer of ciliated cells, containing small, highly refractive, pointed rods, or "rhabdites," and gives rise to deeply-placed mucous cells, which are glandular, and pour out on the surface of the body a fluid in which the cilia vibrate.

The general arrangement of the Digestive system may be seen in Plate VII., and may be compared, especially when the pharynx is protruded, with the gastral system of a Medusa. The "mouth" (there is no anus) is placed almost in the centre of the ventral surface. It leads into a chamber (the peripharyngeal space), divided into an upper and lower division by the insertion of a muscular collar-fold (the pharynx, *ph.*), which may be protruded, its free lips advancing through the mouth, and is then capable of

enclosing, by its mobile fringed margin, prey as large as *Leptoplana* itself. The upper division of the chamber communicates by a hole in the roof * (the true mouth, *g.m.*) with the cavity of the main-gut or stomach (*m.g.*), which runs almost the length of the body in the middle line forwards over the brain (*up*). Seven pairs of lateral gut-branches convey the digested food to the various organs, not directly, however, but only after the food mixed with sea-water has been repeatedly driven by peristalsis, first towards the blind end of the gut-branches and then back towards the stomach. Respiration is largely effected by these means.

The brain, which is enclosed in a tough capsule (*br.*), is placed in front of the pharynx, but some distance behind the anterior margin of the body. It is of an oval shape, subdivided superficially into right and left halves by a shallow depression, and is provided in front with a pair of granular-looking appendages, composed of ganglion-cells, from which numerous sensory nerves arise, supplying the eyes and anterior region. Posteriorly, the brain gives rise to a chiefly motor, nervous sheath (*n.n.*), which invests the body just within the musculature. This sheath is thickened along two ventral lines (*l.n.*) and two lateral lines (*n.s.*), but is very slightly developed on the dorsal surface.

Leptoplana possesses eyes, stiff tactile, marginal cilia, and possibly a sense organ in the "marginal groove." The eyes, which are easily seen as collections of black dots lying at the sides of the brain, may be divided into two paired groups :—1, Cerebral eyes (*e.*), and 2, tentacle eyes (*e.t.*), which indicate the position of a pair of tentacles in allied forms. Each ocellus consists of a capsule placed at right angles to the surface of the body in the parenchyma, below the dorsal muscles, and with its convex face outwards. It is a single cell, in which pigment granules have accumulated. The light, however, can only reach the refractive rods, which lie within it obliquely at their outer ends. These rods are in connection with the retinal cells, and thus communicate by the optic nerve with the brain. The cerebral eyes are really paired, and are directed, some upwards, some sideways, some downwards.

*The roof of the peripharyngeal chamber is hence known as the "diaphragm."

Passing now to the *Termatoda*, we have only space for a very short extract from the Life-history of the Liver Fluke, *Distomum hepaticum*, which produces the disastrous disease, liver rot; it has a distribution as wide as that of a water-snail, *Limnæa truncatula*, the connexion between the two being, as Thomas and Leukart discovered, that this snail is the intermediate host in which the larval, sporcyst, and redia stages are passed through, and a vast number of immature flukes *(Cercariæ)* are developed. These leave the snail and encyst upon grass, where they are eaten by the sheep. . . . Meadows of a clayey soil, liable to be flooded (as in certain parts of Oxfordshire), are the places where this *Limnæa* occurs most abundantly, and these are, consequently, the most dangerous feeding-grounds for sheep.

Although we find every page of the book exceedingly interesting, we are compelled to pass on to the last section, POLYZOA, a section which we are sure will delight every microscopist, as it deals with animals which are scarcely known except to those who are professed naturalists.

"There are but few Polyzoa which have earned the distinction of possessing a popular name, and most of such names as do exist cannot be found outside of Treatises on Natural History. It is true that many of the members of this group have been vaguely called "Zoophytes"; but this term implies no more than

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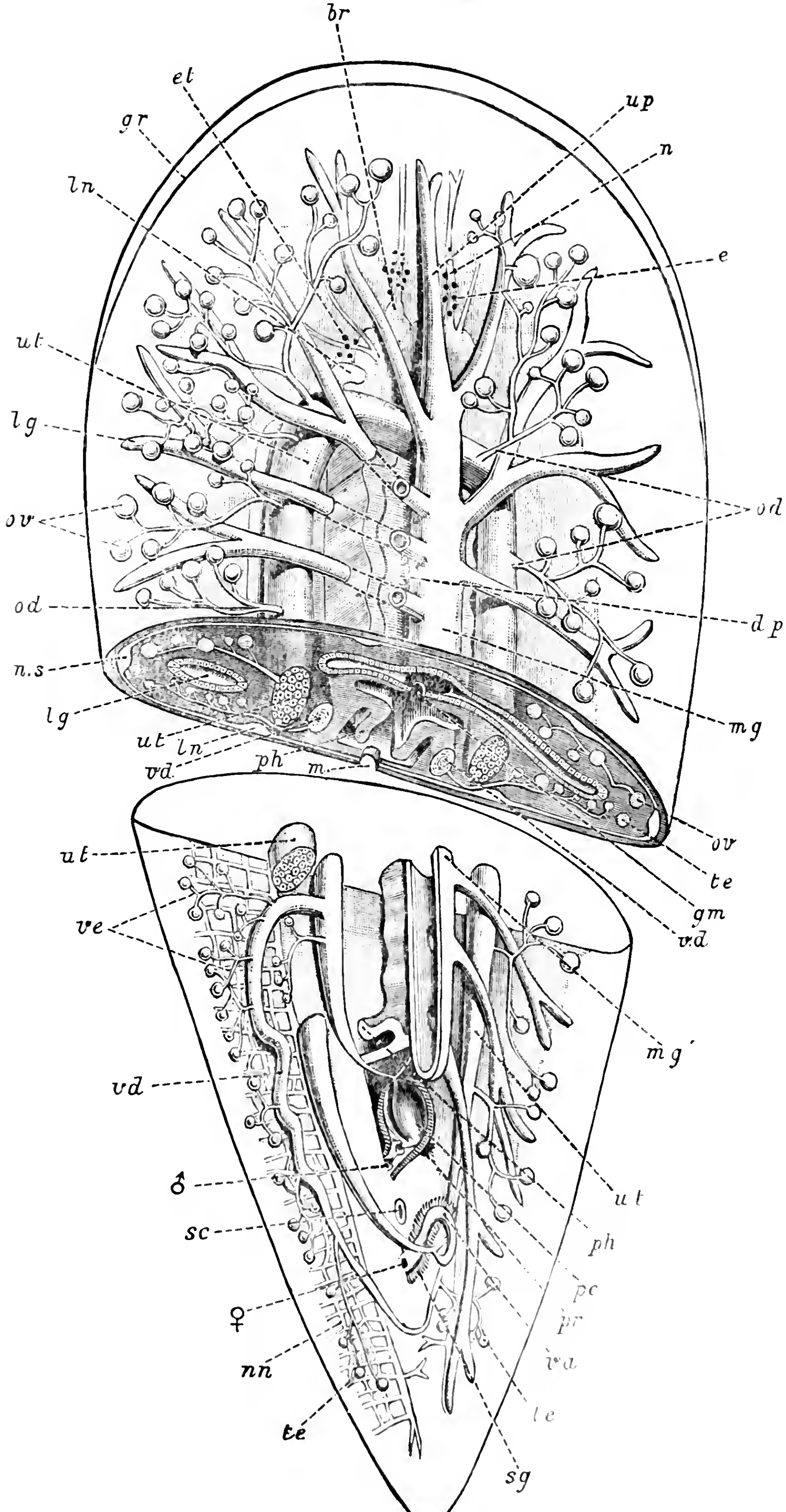
EXPLANATION OF PLATE VII. (see opposite page).

Diagrammatic view of the structure of *Leptoplana tremellaris* as a type of the *Polycladida*. The body is cut across the middle to show the relative position of the organs in transverse section. In the posterior half the alimentary canal has been bi-sected and removed from the left side to exhibit the deeply-placed nervous sheath *(n.n.)*, and the male reproductive organs.

br., Brain; *dp.*, Diaphragm; *e.*, cerebral group of eyes; *e.t.*, Tentacular eye-group; *gr.*, marinal groove; *gm.*, True mouth; *l.g.*, Lateral gut-branch; *l.n.*, Longitudinal nerve stem; *m.*, External mouth; *m.g.*, *m.g.'*, Main gut, whole and bi-sected; *n.*, Sensory nerve supplying the eyes; *n.n.*, Nervous network lying on the ventral musculature; *ns.*, Lateral nerve; *od.*, Oviduct; *ov.*, Ovary; *pe.*, Penis (in section); *ph.*, Pharynx; *pr.*, prostrate, or "granule gland"; *sc.*, Sucker; *s.g.*, Shell-gland; *te.*, Testes; *up.*, Anterior unpaired gut-branch; *ut.*, Uterus; *va.*, Vagina (in section); *v.d.*, Vas deferens; *v.e.*, Vasa efferentia; ♂ Male genital pore; ♀ Female pore.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that they possess a superficial resemblance to certain plants, and it must be remembered that this habit of growth is assumed by many animals that have nothing to do with the Polyzoa. The term "Coralline" is sometimes applied to those calcareous Polyzoa which grow into coral-like forms; and the Tertiary deposit known as "Coralline Crag" is so called from the large number of fossil Polyzoa which it contains.

"The Polyzoa are none the less a most attractive group. Let anyone examine a dry piece of brown, paper-like substance *(Flustra foliacea)* which may be found thrown up on the beach on many parts of our coast. Of this species, the so-called "sea-mat," an old writer says: "For curiosity and beauty, I have not, among all the plants and vegetables I have yet observed, seen any one comparable to this sea-weed."* Viewed with a microscope the frond is seen to consist of two layers, placed back to back, of oblong chambers, each of which is the dried body-wall of a single individual. The whole is obviously a *colony*, and to this fact the term Polyzoa refers. . . . .

There is hardly a more surprising spectacle in the whole animal kingdom than a living fragment of the genus *Bugula*. The colony grows in the shape of a small tree, whose height may amount to several inches; and is characterised in many species by a spiral arrangement of the branches, which makes the genus easy to recognise at first sight (Fig. 1, *A*). The stem and branches are composed of a single layer of Zoœcia, arranged two or more abreast. Each zooecium bears on its outer side a most singular body, termed an avicularium, from its resemblance to a bird's head. Imagine a minute eagle's head attached by a short but flexible neck to the zoœcium. Suppose, further, that the structure moves backwards and forwards in a deliberate fashion, its lower jaw usually open so as to be nearly 180° distant from its position when closed. Suppose that its lower jaw is moved by powerful muscles, which can be distinctly seen inside the transparent head of the avicularium, and that every now and then it closes with a snap, seizing any unfortunate worm which may happen to be within reach with a grasp of iron. The above gives a faint idea of the appearance of a living *Bugula* colony,

*Hooper, quoted by Landsborough, *Hist. Brit. Zoophytes*, 1852, p. 346.

with its hundreds of swaying avicularia, and with its tentacular funnels protruding from their zoœcia, and withdrawing capriciously from time to time.

The Polyzoa, with respect to external form, may be roughly divided into—(1) Encrusting forms, usually calcareous, but sometimes soft; and (2) erect forms, which are either rigid or flexible. This flexibility can co-exist with a highly calcified ectocyst, as in

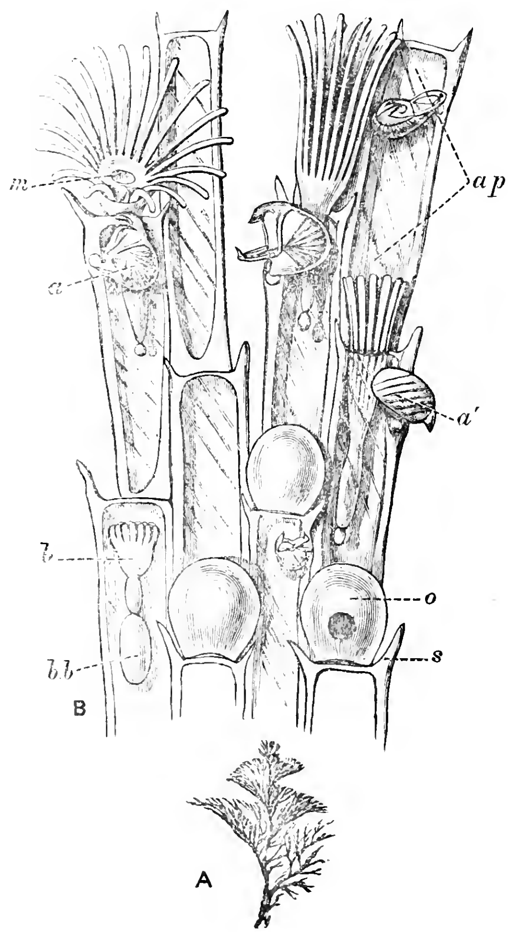

Fig. 1.—*Bugula terminata*, Alder, Plymouth.

A, A small colony (natural size). *B*, Portion of a branch (× 50). *a*. *a′*., Avicularia in different positions; *ap*., "Aperture"; *b*, Polypide-bud, attached by its stomach to *b b*., Brown body; *m*., Mouth, surrounded by the body of tentacles (two individuals to the right show the tentacles partially expanded); *o*., ovicell; *s*., marginal spine. The avicularia of some of the zoœcia have been omitted in *B*.

Crisia (Fig. 2), *Cellaria*, and others, in which the branches are interrupted at intervals by chitinous joints. The coral-like forms may assume the most exquisite shapes, pre-eminent among which are the lovely net-like colonies of *Retepora*. Polyzoa of this type are seldom found between tide-marks, where their brittle branches would be liable to be snapped off by the waves. The *erect* species, which occur in such positions, are flexible, although flexible species are by no means restricted to the zone between tide-marks.

So far as we have up to the present been able to read this book, it has afforded us much pleasure, and we trust that the extracts which, with the publishers' permission, we have been enabled to make, will convey to our readers some idea of the exceedingly interesting nature of the work.

Our best thanks are due to Messrs. Macmillan for the use of the very beautiful electro blocks so kindly lent to us.

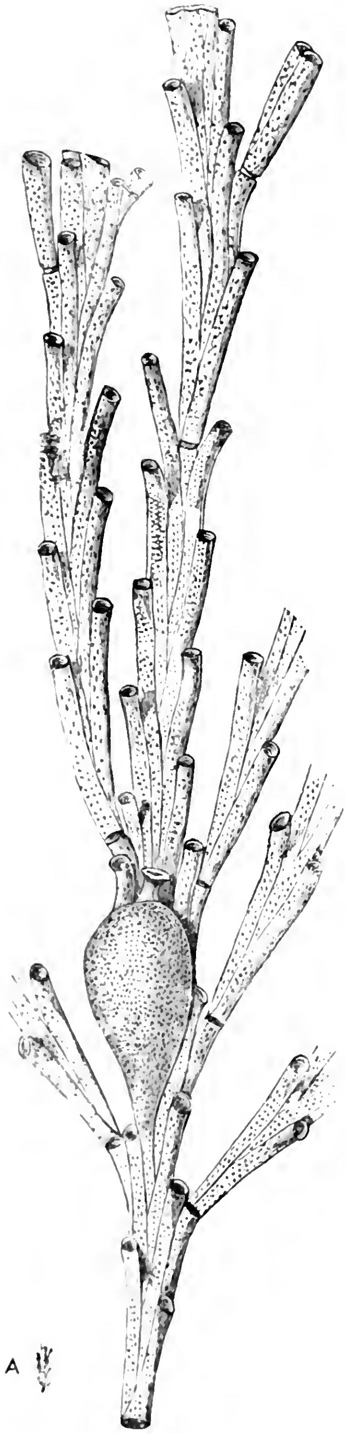

FIG. 2.

Fig. 2.—*Crisia ramosa*, Harmer, Plymouth.—*A*, End of branch (nat. size). *B*, Another branch, × 20, showing the chitinous joints, the tubular zoœcia characteristic of *Cyclostomata*, and the pear-shaped ovicell with a funnel-shaped orifice at the upper end.

A Resume of the Uses of Formalin.*

By George C. Freeborn, M.D.

THIS reagent is also known in commerce under the names of formol and formalose. It is a forty per cent. solution of the gaseous body, formic aldehyde (HCOH), in water. It is prepared by oxidising methylic alcohol and bringing the resulting gas into solution in water. It is non-inflammable. It mixes in all proportions with alcohol and water. Its power of penetration is good. Its keeping properties are good. A series of experiments were instituted to determine this point, with the following results: A forty per cent. solution was kept in open and closed vessels, daily tests being made. The results of these experiments showed that the solutions did not decompose. There was a loss of 1·6 per cent. of formalin, and an increase of 0·1 per cent. of formic acid. Polymerisation took place with the formation of a butter-like mass containing sixty per cent. of formic aldehyde; this dried up into a hard mass which contained eighty-five per cent. of formic aldehyde. Fish and others advise that it be kept in darkened bottles, as the light may decompose it. In an experience of two years I have not noted any appreciable change in the solutions.

Attention was first called to the antiseptic properties of formalin by F. Blum, in 1893. In 1894 Pottevin found that, when formalin was added to cultures of bacteria, their growth was arrested. Cohn also found that solutions and the vapour of formalin killed bacteria both in the vegetative and in the spore stage, but that it had but little action on moulds, unless used in strong solutions. This want of action on moulds has also been noted by many other observers. Miquel, in experimenting with gaseous formic aldehyde, found that it acted as a disinfectant for small and loose objects confined in small spaces, but was not reliable for disinfecting large rooms. Cambier and Brochet also experimented with the gaseous form, with results similar to those of Miquel. Their laboratory

* Read before the New York Pathological Society, March 23, 1896. From the *New York Medical Journal.*

experiments were satisfactory, but their attempt to disinfect a large room did not give perfect results. They, however, demonstrated the fact that layers of dust a centimetre thick were rendered sterile. They also devised a portable apparatus for producing the gas.

Alleger made quite an extensive series of experiments in order to determine the germicidal action of formalin on bacteria. He made use of cultures of the bacillus of diphtheria in Petri dishes. The surfaces of these dishes were sprayed with solutions of formalin varying in strength from 1 to 10,000 to 1 to 100. He found that a solution of 1 to 2,000 prevented the growth of the bacillus, but not that of moulds. Another series of experiments were made with stick cultures in test tubes. Five drops of solutions of formalin, varying in strength from 1 to 20,000 to 1 to 100, were placed on the surface of the culture media in each tube. At the end of forty-eight hours none of the tubes which had been treated with a 1 to 100 or stronger solution showed any growth. A third series of experiments were made with smear cultures, which were allowed to grow for from twenty-four to forty-eight hours, and then they were treated with the above-mentioned solutions of formalin for a few minutes. Cultures were then made from these, with the result that no growth took place from those treated with the stronger solutions.

Formalin has also been used in surgery, obstetrics, and gynæcology, as an antiseptic, but has had to be abandoned on account of its irritating properties. As a preserving agent formalin was first used by the botanists. Cohn experimented with it extensively, and found that the green and red colours of plants were not extracted. At the end of five months his specimens still retained their natural colours, and were not shrivelled. The botanists Sadebeck and Holfert recommend it highly.

It was first introduced into the zoological technique by F. Blum, who obtained excellent results with it as a preservative agent, and it has now come into general use. The excellent results obtained by the botanists and zoologists with formalin as a preservative soon resulted in its introduction into the anatomical and histological technique, and at the present time it is quite generally used. As a preservative agent for gross specimens, it is used in the strength

of two per cent.,* though weaker solutions, from three-quarters to one per cent., have been used. These weaker solutions are objectionable on account of the likelihood of the growth of moulds, and because they cause more or less swelling of the tissues. As the result of the experience of numerous observers, it appears that five per cent. solutions give better results.

The quantity of the solution should be large—a hundred times the volume of the specimen—and the fluid should be renewed at the end of twenty-four hours. In some cases it is well to renew the fluid a second or even a third time. Formalin used in this manner preserves the natural form, the transparency, and, to a certain extent, the natural colour of the specimens. In some specimens the blood-colour appears to be bleached out, but if the preparation is placed in strong alcohol this is nearly, if not entirely, restored. For preserving the blood-colour of specimens, Johres makes use of the following procedure and fluid :

Sodium chloride	1 part.
Magnesium sulphate	2 parts.
Sodium sulphate	2 ,,
Water	100 ,,

To this mixture are added from five to ten parts of a forty per cent. solution of formalin. After the specimen has become sufficiently hardened, pour off the formalin solution, wash the specimen in ninety-five per cent. alcohol, then keep it in ninety-five per cent. alcohol until the blood-colour becomes restored, and finally preserve it in a mixture of equal parts of glycerine and water.

* Bolles Lee (*Anat. Anz.*, xi., 1895, p. 253) calls attention to what he considers an inaccurate use of the terms formol, formalin, and formaldehyde; also to the manner of stating the percentages used. He maintains that the proper way of stating the strength of the solutions is to say "formol or formalin diluted with so many volumes of water."

Parker and Floyd (*Anat. Anz.*, xi., 1896, p. 567) reply to the criticism made by Bolles Lee in the above-cited article. They contend "that for the sake of consistency the same method of expression ought to be used for alcohol —*i.e.*, ninety-five volumes of alcohol and five volumes of water. These expressions seem to us unnecessarily cumbersome, and as they are in no way more precise or less ambiguous to one familiar with the meaning of per cent. than the expressions we used, we prefer them."

Fish makes objection to the use of formalin as a permanent preservative on account of the large amount of water present, which might cause freezing, and advises the addition of an equal volume of alcohol. Hodenpyl,* in using formalin for making sections on the freezing microtome (see below), found that the least trace of formalin left in the specimen prevents it freezing. It would therefore seem that Fish's objection is not valid.

Koehler and Lumière found that if from fifty to a hundred and fifty cubic centimetres of a solution of one volume of formalin, diluted with four volumes of water, were injected into the gastro-intestinal canal of small animals by the mouth and anus, also into the carotid artery, and the animal was kept hung up in the air, in a dry place, for some weeks, it was perfectly preserved without distortion. They performed an autopsy on an animal—a guinea pig—treated in this manner four months after, and found the tissues and organs perfectly preserved. Dr. Henry Power* has treated the bodies of children in a manner similar to this with good results. Professor George S. Huntington informs me that he has used formalin for the preservation of organs. He injects a solution of from two to twenty-five per cent. into the blood-vessels, and the result is a perfect preservation of the form and colour of the organ. He has found that it is of no use for preserving dissecting material.

For the preservation of brains, formalin has given excellent results. The fresh brain is placed in a ten per cent. solution, and at the end of ten days it will have sufficiently hardened to permit of the making of thick sections for demonstration of the gross anatomy, the distinction between the white and grey matter being more sharply defined than when alcohol is used.

Parker and Floyd confirm the observations of Lanzilotti-Buonsanti, Hoyer, Hoffer, and others, in regard to the swelling of the brain when formalin alone is used. In a sheep's brain they found this swelling to be forty per cent. of its original volume. In order to correct this defect they experimented with various reagents in combination with formalin. They finally found that a mixture of six volumes of ninety-five per cent. alcohol and four volumes of a

* Personal communication.

two per cent. solution of formalin gave nearly perfect results. Sheep's brains hardened in this mixture retained their original colour and form, and were very little increased in volume. "A brain that before treatment (June 20th) measured one hundred and one cubic centimetres, when finally prepared (July 15th) measured one hundred and three cubic centimetres."

Fish states that an excellent hardening of the brain may be obtained with the following mixture:

Water	2,000 c.c.
Formalin	50 „
Sodium chloride	100 grms.
Zinc chloride	15 „

The specific gravity should be about 1·05. The brain is left in this mixture for a week or ten days. The blood-vessels and cavities should be injected with the fluid if possible. After the end of the ten days the brain is transferred to formalin, fifty cubic centimetres, and water, two thousand cubic centimetres, where it may be kept indefinitely; or, after being a week in this fluid, it may first be transferred to fifty per cent., then to ninety per cent., and finally to ninety-five per cent. alcohol. He has also treated portions of the adult central nervous system by this method, and afterwards with mercuric chloride, picro-aceto-sublimate, and chromacetic-acid mixtures, with good results.

For hardening eyes Leber used formalin mixed with water in the proportion of one to ten. The natural colour and transparency of the organ were retained. The cornea and lens became but slightly cloudy. In his opinion, the fine structure was as well preserved as with Müller's fluid. If the eyes were placed in alcohol the cornea and lens became opaque. I have employed formalin in a five per cent. solution for this purpose with the same results. As a hardening agent for microscopic work, formalin has been used very extensively, the strength of the solutions employed varying from one per cent. to the full strength—forty per cent. As the results of many observations, it may now be said, with possibly one or two exceptions, that formalin alone is an unfit reagent for hardening tissues for microscopic work. It was condemned by Hermann in 1893; Lachi states that it has an injurious

effect on connective tissues, smooth and striated muscle, and embryos. Many other observers condemn its use without being so specific as Lachi.

The exceptions, where it gives satisfactory results, are mucous membranes and the central nervous system. I have used it in five per cent. solution for hardening cystic adenoma of the ovary with good results; also for the mucous membrane of the uterus. Lachi, who has condemned its use for all other tissues, speaks well of its action on the central nervous system. Van Gieson has employed it in four, six, and ten per cent. solutions for hardening the central nervous system. The ganglion and nerve fibres were well fixed. Sections stain well with Weigert's hæmatoxylin method. He has also used it for hardening the central nervous system for after-staining with Rehm's modification of Nissl's method. The results were good, but not quite so sharp as with alcoholic hardening.

The best results for microscopic work are obtained when formalin is combined with other fixing reagents. When it is used in combination with the chrome salts, more rapid penetration is obtained, whereby the time required for hardening is shortened. I have used a solution of formalin in Müller's fluid made as follows:

Potassium dichromate	2 grms.
Sodium sulphate	2·5 „
Two per cent. solution of formalin ...	100 c.c.

With this fluid I have obtained excellent preservation of the ovary, the uterus, etc. At the end of forty-eight hours the specimen is cut into slices an eighth of an inch thick; these are washed in water for two hours; they are then placed in alcohol for twelve hours, and then carried through the usual processes of embedding in celloidin. Specimens hardened in this manner show no shrinkage, and the tissue elements are well preserved.

Landowsky recommends the following fixing fluids for mitotic figures in cells:

1.	Water	20 c.c.
	Alcohol (ninety-five per cent.) ...	10 „
	Formalin	3 „
	Hydric acetate	0·5 „

2. Water	30	c.c.
Alcohol (ninety-five per cent.) ...	15	,,
Formalin	5	,,
Hydric acetate	1	,,

Probably the most successful use of formalin in histological technique is its substitution for osmic acid in the osmium-dichromate fluid used in Golgi's silver method for the central nervous system. This substitution was probably first made by Dr. O. S. Strong, though it has been recommended by Lachi and others. Strong employs the following mixture:

Potassium dichromate (3·5 to five per cent. solution)	100 vols.
Formalin	2·5 to 5 vols.

After the specimen has been in the solution for several days it is transferred to a one per cent. silver nitrate solution; or, at the end of two days, it is transferred from the formalin dichromate mixture to the following:

Potassium dichromate (five per cent. sol.)	2 vols.
Formalin	1 ,,

After remaining in this fluid for from twelve to twenty-four hours, it is placed in the silver solution. The advantages of this method are, that the stage of hardening is prolonged, the stage favourable to impregnation lasts longer, and the results are more certain. For embryonic tissue he does not consider it as good as the osmic dichromate mixture. Fish has used the above-described method, but thinks he has obtained better results with the following:

Müller's fluid	100	c.c.
Formalin (ten per cent.)	2	,,
Osmic acid (one per cent.)	2	,,

Strong has also used formalin as an injection medium for hardening brains *in situ*. He uses formalin diluted with an equal volume of water. This he injects into the cerebral vessels until it runs out of the cut jugulars. After a few minutes he makes a second injection, then a third, and even a fourth, at intervals of fifteen minutes. The brain is then removed from the cavity of the skull. The swelling which usually occurs when formalin is used does not take place. Sections from brains hardened in this man

ner may be stained by either the Weigert or the Golgi method. When the Golgi method of staining only is to be used, an equal volume of a ten per cent. solution of potassium dichromate is added to the formalin in place of the water.

Dr. T. S. Cullen has devised two methods for using formalin in connection with frozen sections. They are as follows :

Method I.

1. Keep sections made with the freezing microtome in a five per cent. aqueous solution of formalin for three to five minutes.
2. Keep them in fifty per cent. alcohol for one minute.
3. Keep them in absolute alcohol for one minute.
4. Wash them in water.
5. Stain them in hæmatoxylin for two minutes.
6. Decolourise them in acid alcohol (1·5 per cent. HCl).
7. Wash them in water.
8. Stain them with eosin for twenty seconds.
9. Place them in ninety-five per cent. alcohol.
10. Pass them through absolute alcohol, clear them in creosote, or oil of cloves, and mount them in Canada balsam.

The blood being lost in the frozen sections, the defect was overcome by fixing the tissue in formalin, and then making frozen sections as in

Method II.

1. A piece of tissue $1 \times 2 \times 5$ centimetres is kept in a twenty per cent. aqueous solution of formalin for two hours.
2. Frozen sections are made.
3. Keep them in fifty per cent. alcohol for three minutes.
4. Keep them in absolute alcohol one minute.
5. Wash them in water and stain them in hæmatoxylin for two minutes.
6. Decolourise them in acid alcohol (1·5 per cent. HCl).
7. Wash them in water.
8. Stain them in eosin for twenty seconds.
9. Place them in ninety-five per cent. alcohol.
10. Pass them through absolute alcohol, clear them in creosote or oil of cloves, and mount them in Canada balsam.

Method I. is used for diagnosticating bits from tumours, and

it is possible to make a report in fifteen minutes. Method II. is used mostly for the examination of uterine curettings. The author's practice is to have bottles containing a ten per cent. solution of formalin in the operating room. The curettings are immediately placed in one of these, and by the time they reach the pathologist they are hard enough to make frozen sections of.

Bender has also used formalin for making frozen sections, not for preliminary hardening, as in Cullen's method, but for completing the hardening of specimens that have already been in alcohol. He places pieces of tissues, two millimetres thick, that have been in alcohol, in a one per cent. solution of formalin, and keeps them there until the alcohol is completely removed. This requires from half an hour to an hour. He then washes them well in water and makes frozen sections. The tissue, he states, is rendered soap-like in consistence by the action of the formalin.

Ohlmacher states that formalin, when used in from two to four per cent. solutions, acts as a powerful mordant for aniline dyes. Cover-glass preparations are treated for one minnte with the solution, washed well in water, and then stained in the cold. Or it may be used instead of aniline oil or carbolic acid as a menstruum for dissolving the dyes. One gramme of fuchsine or other aniline dye is dissolved in ten cubic centimetres of alcohol, and this is added to one hundred cubic centimetres of a four per cent. solution of formalin. Formalin methylene blue, made by dissolving one gramme of methylene blue in one hundred cubic centimetres of a four per cent. solution of formalin, makes an effective stain. A saturated solution of safranin in a four per cent. solution of formalin gives a beautiful double stain when used after the formalin methylene blue. Nuclei stain blue, plasma stains reddish.

S. H. Gage has used the following solution as a dissociating agent with good results:

Normal salt solution	...	...	1,000 c.c.
Formalin (forty per cent.)	...	...	2 „

Formalin has been used by Hauser for preserving plate and tube cultures of bacteria. His method is as follows: Plate cultures in Peri's dishes have a piece of filter paper placed under the cover, which has been moistened with ten to fifteen drops of formalin.

The plates are then placed in a closed vessel, in the bottom of which is laid paper or cotton saturated with formalin. After twenty-four hours the cultures are fixed. Test-tube cultures are closed with a plug of cotton that has been wet with formalin, and then placed in a closed chamber as above. After twenty-four hours they are removed and sealed with sealing wax, when a permanent preparation is obtained. Colonies from plate cultures may be permanently mounted by the following procedure: The selected colony is cut out of the plate and placed on a slide and covered, and then a little of the melted medium is run under the cover. The slide is then exposed to the action of the vapour of formalin for twelve hours. Formalin renders ordinary culture media, gelatin, and that fluidified by bacteria, non-liquefiable by heat. The above-mentioned method of preserving bacteria has been employed successfully by Alleger, Cheesman, and many others. I am informed by Dr. Cheesman that cultures treated in this manner by him a year ago are still well preserved, but some of the chromogenic forms have lost their colour to some extent.

DISPLACEMENT OF SPINES.—T. Kirk shows that the effects of introduced animals and plants upon the old fauna and flora of New Zealand go to prove the truth of Darwin's theory of the "survival of the fittest." Native plants have been unable to survive the changed conditions accompanying the advent of civilisation, and their places have been occupied by an army of encroaching weeds. Further, the invading army of plants has brought in its train a still more dangerous host of animals, those whose agency is most dreaded being members of the Invertebrata: the mussel scale, the black scale, and many others, together with numerous species of plant-lice belonging to lowly-developed forms of Insects. Higher in the scale are the Hessian fly, wire-worm, turnip fly, and others, while numerous species of earthworms, mollusca, birds, and even mammals, affect alike both fauna and flora. More than five hundred plants have become naturalised in the colony, but it seems probable that the limit of encroachment is nearly reached, so far as introductions from Europe are concerned. There are numbers of "repeats" also, for out of one hundred and three species of plants recently introduced with ballast from Buenos Ayres, eighty-six were already naturalised in the colony.—*Journal of Botany.*

A Review of the Golgi Method.*

By Oliver S. Strong.

THE advent of the Golgi method in nerve histology has so greatly enlarged our knowledge and altered our conceptions of the structure of the nervous system in many respects, and the method, or methods, itself has such well defined peculiarities, that it has been thought that a general review of it from the technical side would be of interest and perhaps of use, especially in view of the very considerable number of investigators now employing it.

The review does not aim at any originality of treatment, but is simply a compilation from available literature of its various modifications and applications. It may be stated that it does not include Golgi's arsenic-gold chloride method, nor even the application of the bichromate-silver methods to the structure of medullated nerve-fibres.

It has seemed most appropriate to begin the review with a translation of the technique of Golgi's methods as given by Golgi himself, principally in his work, *Studi sulla fina anatomia degli organi centrali del sistema nervoso*, pp. 181–208. The translation is made, however, from the German edition of Golgi's works (" *Untersuchungen über dein feineren Bau des centralen und peripherischen Nervensystems*," pp. 169—182, translated by R. Teuscher). Golgi's own account of the technique is still the most complete, nor does it seem to be by any means universally understood how completely Golgi worked it out, and how largely we owe not only the discovery, but also the development of the method to him. It is for these reasons as well as for the many valuable hints contained therein that the translation of this rather extensive account of Golgi's is here given.

" The particular methods to which I owe my most noteworthy success are the following :—(1) The method of black staining by successively treating the pieces (of brain tissue) with bichromate of potassium or ammonium and silver nitrate. (2) The method of the successive action of a mixture of osmic acid and bichro-

*From the *Journal of Comparative Neurology.*

mate and of silver nitrate. (3) The method of the combined action of bichromate of potassium or ammonium and bichloride of mercury. (The stain appears black by transmitted, metallic white by reflected light.)

"(1) *The method of the combined action of bichromate of potassium and of silver nitrate.* In the series of methods which I have specially employed this is, in a manner, the fundamental one The others are only variations of this, devised to shorten the time of the preliminary treatment, to make the preparations more stable, to vary the results in various ways, especially to obtain a greater extension of the reaction and to cause the reaction to affect one or another species of the elements or a part of them.

"I consider it to the point to call attention to the fact that the procedure of the microscopical technique which I will describe, although it rests essentially upon the action of silver nitrate, has nothing in common with the usual method of staining the intercellular substance of endothelium, epithelium, and connective tissue, brown or black. In the latter method dilute solutions of silver nitrate are applied immediately to the fresh tissue, exclusively to the surface of membranes or membranous tissues of slight thickness (aponeurotic plates, substance of the cornea, intima of vessels), and light exerts an important influence upon the reaction whereby the blackening of the combination which the silver salt forms with the ground substance is brought about. With my method the light has nothing to do, and the reaction takes place through the gradual penetration of the silver salt into more or less voluminous pieces which have been previously treated with bichromate. The black-staining of the various elements composing the nervous tissue results from a reducing action which the elements themselves exert, under the influence of the bichromate, upon the silver salt.

"The procedure necessary to bring about the black-staining of the elements of the central nervous system consists essentially of two parts:—

"*(a) Hardening of pieces in a solution of potassium bichromate.*

"*(b) Immersion of the hardened pieces in a solution of silver nitrate.*

"*(a) Hardening in bichromate.* Although there are no especial

rules for the hardening other than those which must usually be followed to obtain a good uniform hardening, yet it is this part of the process which requires the most care. This is the more so because the time necessary to harden the pieces to the degree required for the action of the second reagent varies very considerably according to different circumstances and especially according to the temperature.

"For the first immersion of the pieces, I use either a simple two per cent. solution of potassium bichromate or the usual formula of Müller. (The reagents should be pure.) There must be an abundant quantity of fluid in proportion to the quantity of pieces to be hardened.

"The part of the brain or spinal cord to be treated is cut into tolerably small pieces (about 1 to 1½ ccm.). It is important that the pieces be fresh; the fresher the pieces, the better the results. It is well to use, preferably, the brains of animals just killed, yet satisfactory results can also be obtained twenty-four to forty-eight hours after death. It is hardly necessary to say that the pieces must be cut regularly and in definite directions (according to the part to be studied) so as to permit orientation as to the part and the location of the elements in the future study.

"That the hardening may proceed with some rapidity and be uniform, it is well to successively increase the concentration of the fluid, raising the quantity of bichromate from 2 per cent. to 2½, 3, 4, and 5 per cent.

"Whether the fluid is increased in strength in hardening the pieces, or remains the same strength, it is always necessary to change it from time to time to avoid the formation of moulds, which, as is well known, develop abundantly in bichromate solution when the pieces are to some extent neglected. For the same reason it is advantageous to place in the vessels with the pieces a small quantity of some substance which will prevent the growth of hyphomycetes, as camphor, salicylic acid, etc. The most important point, and at the same time the most difficult to determine in order to obtain good results with this method, is the length of time during which the pieces must be kept in the bichromate solution before one passes on to the second part of the process—the reaction with the silver nitrate.

"The proper duration of immersion for the pieces to obtain that degree or particular kind of hardening which is best fitted to secure, when they are laid in the silver solution, a fine and diffused action upon the various elements of the nervous system varies according to various conditions. These are the strength of the fluid, the condition of the pieces, the quantity of fluid, temperature, and, consequently, the time of the year.

"The differences arising from the strength and quantity of the fluid may be eliminated by paying strict attention to the strength of the fluid, by using covered vessels, and preserving the same ratio between the number of pieces and quantity of fluid.

"The influence of temperature upon the results of the reaction is more important; indeed, practically, all the uncertainties of the method depend upon this. For example, to mention extremes, good results (which, with the progressive changes, of which I shall speak later; continue to appear and extend) can be obtained in the warm season after an immersion of fifteen to twenty days and seldom after thirty to forty or fifty days; on the other hand, in the cold season, good results are scarcely obtainable after an immersion in bichromate of less than one to one and a-half months. The reaction (with the progressive accompanying changes) may then continue to manifest itself for two, three, or four months, provided, of course, the pieces are preserved according to the rules given above. It is almost superfluous to say that during the gradual change from the warm to the cold season and *vice versa* corresponding changes in the appearance of the reaction take place. It is not easy to remedy these temperature changes, especially because these changes of environment are united with the other causes of uncertainty mentioned, and so act that observations made upon one series of pieces never agree closely with those made upon another series. A warm chamber, of which I shall speak later, cannot bring about the accuracy sought for.

"The surest means of remedying these inconveniences is the persevering repetition of the process—*i.e.*, one must have a good number of pieces available, bring several from time to time into the silver solution, and then ascertain whether they are in the desired condition. If a good reaction has taken place, one continues the trials at regular intervals in order to obtain all the stages

of the reaction, which constitute an advantage of this method. It is self-evident that the different trials must follow each other at intervals differing according to the time of the year. In the warm season, when the requisite hardening is reached much earlier, the trials must follow each other more quickly ; in the cold season, on the other hand, when the desired hardening is first reached after a month, the trials can be made at intervals of eight to ten days, beginning with the time when one, according to my direction, has ground to assume that the tissue has begun to enter the desired condition.

"*(b) Transference of the hardened pieces into the solution of silver nitrate.* Although the various conditions of which I have spoken make it impossible to state with complete accuracy for how many weeks or days the pieces must be brought from the bichromate into the solution of silver, this is no ground for concluding that the method is subject to excessive uncertainty. All difficulties are overcome, and one can be absolutely sure of always obtaining excellent results by the simple procedure of steadily extending the trials with every series of pieces. The difficulties are thus very like those which one encounters in the employment of all other impregnation and imbibition processes, not excepting the simple carmine staining, in which, as is well known, one only reaches quick and certain results after repeated trials when he has learned to know the nature of the staining fluid and of the pieces to be stained.

"I usually employ a ¾ per cent. silver solution ; yet I will remark that it is not necessary to adhere closely to this formula to obtain the reaction. A slightly stronger or weaker solution does not affect the result. I will also add that a slightly weaker solution (½ per cent.) appears to be somewhat more suitable (giving finer results though confined to fewer elements) so long as the pieces have not yet reached the complete hardening, while a slightly stronger solution (to 1 per cent.) appears better adapted for pieces whose hardening has progressed a little too far.

"The quantity of the silver solution to be used must vary with the number and size of the pieces to be laid therein, but must be relatively abundant. For two or three pieces of about 1 ccm., I use about half a beaker *(bicchiere)* of the fluid.

"The moment the pieces are brought from the bichromate into the silver solution, a copious yellowish precipitate of silver chromate results. The formation of this precipitate takes place, of course, at the expense of the strength of the fluid, inasmuch as, through the formation *in loco* of the insoluble precipitate, a more or less considerable portion of the silver salt is deposited. This changes, naturally, the relation (osmotic as well) between the fluid which should penetrate into the piece and the inner portions of the piece. It might happen that the whole or the greatest part of the silver would be precipitated from the solution, which would result in the more or less complete absence of the reaction. To avoid this mishap, it is expedient to first wash the pieces in which the reaction is sought in a weaker solution of silver. I use for this purpose, from motives of economy, silver solutions which have already been used on other pieces without the silver having been fully neutralised. When this washing has been continued until the pieces cause no more precipitate when brought into a clear solution,* they are finally placed in the fluid of the proper strength. From there on, the preparation usually requires no especial attention, for if the solution is present in copious quantity it is sufficient to let the fluid penetrate into the interior of the piece. Yet it is well to consider that it is sometimes expedient, with pieces thoroughly saturated with bichromate through a long sojourn therein, to change the solution for a fresh one after the pieces have been in the first solution six to eight hours. This must be done whenever the fluid assumes a yellow colour, which shows that the silver nitrate is neutralised. In this case the reagent can no longer possess the necessary strength to penetrate to the interior of the pieces.

"I have already said that this reaction, through which the black staining of the elements is brought about, has nothing in common with that which stains the intercellular substance under the influence of light. I now need to add that it is entirely the same whether the pieces in our method are kept in the light or in the dark; the reaction which is brought about through the gradual

* Several minutes should be elapsed to test this, inasmuch as the discolouration of the silver solution by the reddish precipitate sometimes takes place rather slowly, both in this and in the rapid method.—*Author.*

penetration of the silver into the interior of the tissue takes place equally well in both cases. The only rule relating to keeping the pieces in the silver, which experience has shown to be in some manner useful, is that they should be kept in water in a well-heated room. I place the vessel on a table which is not far from the stove of the laboratory.

"The pieces must remain, as a rule, in the silver solution for twenty-four to thirty hours; in exceptional cases forty-eight hours. The period of twenty-four to thirty hours must form the rule, although, when the time of hardening has been correctly hit upon, the reaction may be well advanced in two to three hours. In such cases one may say that the reaction begins immediately, at least in the superficial layers, to extend gradually deeper with the deeper penetration of the fluid. In the exceptional cases, when it is best to leave the pieces forty-eight hours and longer in the nitrate solution, and where it is well to change the solution a second time, one must regulate his procedure by the results of a microscopical examination of some superficial sections from which the condition of the reaction may be inferred. Moreover, one can perceive, from the yellowing of the fluid, whether the reagent is nearly neutralised.

"As for the rest, it is to be remarked that an indefinite sojourn of the pieces in the silver solution lasting days, weeks, or even months is in no way injurious to them; on the contrary, this is a suitable means of preservation for pieces destined for a particular investigation of long duration.

"One of the most interesting peculiarities of the process which I here describe consists in the fact that, while the brownish black stain acts quite similarly upon all elements of the nervous tissue (various kinds of ganglion cells, nerve-fibres, elements of neuroglia, and walls of vessels), yet in reality the staining of all these at one time forms an exception—*i.e.*, when the elements are in a certain state of hardening which one only happens upon accidentally in a great number of trials. As a rule, the reaction appears only partially—*i.e.*, it affects only one or another layer with gradations and combinations which one may term endless.

"This peculiarity does not detract from the method, but is rather among its advantages, for if the reaction affected all kinds

of elements at the same time, there would evidently arise such an inextricable confusion that it would be impossible to orient oneself in respect to the locations and relations of the individual parts. When, for example, in one preparation the cells especially are stained black, in another principally the neuroglia, together with the vessels and some groups of nerve cells, it is evident that one can, by the comparison of many preparations, obtain a general view of the various peculiarities of the arrangement and relations to each other of the individual species of elements and of the connection of the structures of various regions.

"This is so much the more the case since these combinations and gradations also appear in certain layers and different zones, into which one is accustomed to divide different regions of the nervous system. In the cortex, for example, the reaction appears, with the various combinations above mentioned, sometimes in the superficial or middle, sometimes in the deep layers.

"A law undoubtedly exists governing the manner of development of the black stain and the succession of the reaction among the various kinds of elements, and it would be interesting to learn to know this so as to be able to bring about one or another result at will; but it is extremely difficult, if not impossible, to attain this. This difficulty will be readily comprehended when one reflects that the diversity of results is brought about not only by the conditions given already, but also by the unequal hardening action of the bichromate, so that the individual layers of the pieces are in different conditions. In the individual pieces the degree of hardening may increase from centre to periphery, so that a number of the above combinations and gradations may appear in one piece.

"The following approximate rule, however, may be accepted for the way the reaction enters the various elements of the nervous tissue when a number of similar pieces are successively subjected to the action of the silver nitrate. Then stain in the following order:—

"1.—*The bundles of nerve fibres.* At the same time with the staining of these fibres some scattered ganglion cells which lie dispersed in the gray matter appear.

"The staining of the nerve-fibres at the beginning shows little

delicacy, the reaction being, so to speak, tumultuous, but gradually gains in fineness with progressive hardening (always, however, after a more or less brief period of time). Then the individual fibres (axis cylinders) composing the bundles can be well seen, and also individual fibrillæ streaming from the bundles, the finest details of whose course and branching can be seen at a glance.

"2.—*The ganglion cells.* The ganglion cells of the superficial layers always stain first (*e.g.*, in the cortex the small cells of the peripheral zone), but at the same time with them also some cells irregularly scattered in the inner layers. As the reaction progresses, it affects the cells rather than the fibres, and the tendency is for the stain of the cells to become more general and to extend from the periphery inwards. Then, too, while the reaction is becoming more complete among the cells of the deeper layers, it becomes always more limited among those of the superficial layers.

"With the cells as with the fibres, the reaction is at first coarse and little fitted to bring to view certain interesting details. For example, the nervous process is not stained at first to any great extent, and usually only a short piece of it is to be seen, so that neither its course, direction, nor its few or numerous branches can be perceived. With the gradual progress of the reaction the nerve-cells are displayed more clearly, and the finest subdivisions of their protoplasmic as well as their nervous processes appear.

"3.—*Cells of the neuroglia.*—An interesting reaction occurs in the cells of the neuroglia; it may be said that it takes place in pieces suitably hardened in bichromate from the beginning of the phase to the end. In fact, at both the time when the fibres predominate and when the cells predominate, individual neuroglia cells or groups of them are to be seen showing the characteristic reaction of the silver nitrate (coffee-brown or yellowish). Besides, with this species of element the reaction only becomes fine and diffused in a somewhat advanced period of hardening, so that their typical form and relations are plain. The reaction in neuroglia cells takes place for a long time beyond the time favourable for staining nerve-cells.

"The finest reaction for the nerve-cells, especially for the nervous processes, occurs at a somewhat advanced stage of hardening, namely, when, with the advance of the reaction among neuroglia

cells, it is limited among the ganglion cells. It is precisely among isolated blackened cells that the stain of the individual functional (axis-cylinder) processes is finest; one can observe the smallest details of their course and branching. I must again recall that the reaction must be produced in a series of pieces which have consecutively received suitable treatment in order to learn to know all its phases.

"After we have so circumstantially laid down the fundamental rules of procedure, it would be superfluous to go into particulars about the differences obtaining between the different provinces of the central nervous system (the *cortex cerebri*, the so-called ganglia of the base, the cerebellum, the spinal cord). I only remark here that, under similar conditions, pieces from the cortex reach in bichromate the suitable state of hardening somewhat sooner than those from the cerebellar laminæ, that the latter reach it a little later than pieces of the spinal cord, and that finally the so-called ganglia of the stem reach the proper hardening still somewhat later than the parts named.

"A last remark. When the above-described peculiarities of the process are considered, it is intelligible how it often happens that the reaction appears only in one part of the piece. For example, it is absent in the superficial layers, where there is, as a matter of fact, more often than otherwise only an irregular precipitate, and is at present in the interior or *vice versa*. One must remember this, and when, very likely, the first sections made near the surface show nothing of interest, one must not thereupon conclude that the reaction has failed, for it often happens that such preparations, in which only single, isolated cells are stained, are among the most instructive for details of the individual elements.

[TO BE CONTINUED.]

WE ARE GLAD to be able to state that Mr. Vine will continue his very interesting series of papers on "The Predacious and Parasitic Enemies of the Aphides" in an early part of the Journal.

Microscopical Technique.

Preservation of Structures by Formalin.*—Hauser refers to his former experiments, in which it was shown that cultures could be preserved by means of formalin vapour. Gegner proved that gelatin exposed for a long time to formalin vapour does not become fluid at the body heat. The author further shows that at no temperature can it be liquefied. At the same time, the gelatin is in this way permanently sterilised and remains unchanged. Thus, formalin is a most useful means of preserving cultures, the only condition being that they should not be allowed to dry up. It is also specially adapted for microscopic culture preparations. After thus fixing the gelatin in not too thick a layer, the part which it is desired to keep should be detached with a sharp spatula. This is put on a slide with gelatin of similar composition, and a cover-glass applied. The preparation is then put into the formalin vapour chamber for twenty-four hours. Lac is applied round the cover-glass to prevent drying. Cultures can also be made on slides in the first instance. The author has tried these methods with success in the case of many micro-organisms. The culture can also be stained by a weak, watery fuchsin solution. Another method is to let the coloured gelatin culture dry upon the slide, and then mount in Canada balsam. The colony should in all cases lie in the centre of the gelatin.

Bleaching Vegetable Sections.†—Coles' method of preparing sections for staining is to bleach by means of a solution of chlorinated soda, the length of time varying according to the condition and nature of the tissues. Wash several times in fresh water, and finally with water containing eight or ten drops of nitric acid to each half-pint. Transfer sections to alcohol for an hour before staining.

Oil of Cassia as a Medium.—Oil of cassia has a higher refractive index than cedar oil, and Dr. H. G. Piffard finds it brings

* *Munch. Med. Woch.*, Aug. 29, 1893, in *Brit. Med. Journal*, Nov. 4, 1893.

† *Methods of Microscopical Research.*

objects examined in it into sharper contrast. In a paper read before the New York Academy of Medicine, he stated that he had worked with a sample having a refractive index of 1·593. Bacilli examined in this oil exhibited an unrivalled brilliance and sharpness of contour. The minuter details, also—such as spores, flagella, etc.—are shown with a distinctness impossible in cedar oil. The oil of cassia, like the oil of cloves, tends to abstract the colour from the bacilli stained with some of the aniline dyes, a disadvantage not shared by cedar oil ; but it is stated that this does not take place with sufficient rapidity to interfere with the diagnostic examination.—*Pharmaceutical Journal.*

Structure of Yeast.*—P. Dangeard claims to have proved that the *Saccharomyces cerevisiæ* possesses a well-characterised nucleus. His material was fixed with absolute alcohol and stained with hæmatoxylin, and the details were rendered evident by the aid of a Zeiss' apochromatic objective of 2 mm. focus. The yeast cell under these conditions, is said to show, under the limiting membrane, a thick bed of dense homogeneous protoplasm coloured by the reagent. This protoplasm encloses a large vacuole, and the nucleus is found lodged in the thickness of the protoplasmic bed, being described as spherical, limited by a very clear nucleus membrane, and containing in the centre a large nucleolus strongly coloured. The mass of hyaloplasm between the nucleolus and the membrane is said to remain free from colour, and one or more threads of chromatin may frequently be seen in immediate contact with the nuclear membrane. When the operation of budding takes place, the bud about to separate and form a new cell makes its appearance at a spot diametrically opposite to that where the nucleus is situated. It is almost spherical, and, like the mother cell, contains a mass of protoplasm enclosing a vacuole. It is attached to the mother-cell by a very fine pedicel, which subsequently disappears. Up to this stage the nucleus shows no change, but now it moves towards the point of attachment of the pedicel and splits into two parts, each of which consists of half the nucleolus surrounded by a clear hyaloplasmic zone. One of

* *Comptes Rend.*, cxvii., 68.

these new nuclei then becomes united to the pedicel as at the mouth of a funnel, and a slender thread of chromatin presently extends from the point of union to the daughter cell. There it becomes swollen, and gradually attracts to itself all the chromatic granules. During the passage through the pedicel, the nucleus shows no trace of nuclear membrane, but subsequently this appears as usual. The nucleus remaining in the mother cell is carried to another point where a fresh bud has formed. When growth is rapid, several buds may be observed in a cell at the same time, but they are of different ages, having been formed successively in the manner described, each new budding corresponding to a fresh division of the nucleus.—*Pharm. Journ.*

Detection of Cholera Bacillus.*—Koch's former method of examination, though certain in its results, was somewhat tedious, and a more speedy method has been tried at the Institute for Infectious Diseases, Berlin. A little mucus from the liquid part of the object to be examined is fixed on a cover-glass and stained with Ziehl's fuchsine solution. Cholera bacteria, in such a preparation, would either occur alone or mixed with ordinary intestinal bacteria, especially *B. coli.* They are said to lie as a rule where the mucus is drawn into threads, and in the characteristically formed groups the individual bacilli lie in one direction. But even when the bacteria are scattered, and perhaps mixed with the *B. coli*, it is stated that Asiatic cholera may be diagnosed with certainty. Only when the specimen is a very mixed one is there any uncertainty in the matter. As regards the method of culture adopted, a peptone process is now employed by Koch in which the lumps of mucus are placed in a one per cent. sterilised peptone solution in a reagent glass, and kept at a temperature of 37° C. When the preparation begins to grow turbid, the bacteria may be discovered on the surface (in about six hours) if they are numerous in the test specimen, but when only few they are discovered later mixed with other bacteria. These peptone cultivations are said to have given positive results when gelatin plates failed, but the most satisfactory procedure is to combine the two processes.—*Pharmaceutical Journal.*

* *Zeit. f. Hygiene*, through *Med. Press*, Vol. CVI., p. 643.

Stains for Vegetable Tissues.*—Dr. E. Vinassa has investigated the value of aniline colours for staining vegetable tissues, and divides them into three groups only: safranin, congo-red, benzopurpurins, etc.; those affecting lignified tissues, collenchyma vessels, and nuclear sheaths—vesuvin, Victoria green, chrysoidin, violet, methyl green, fuchsin, etc.; and stains that merely differentiate, such as Victoria blues B, RRRR, and BB, which colour the thickened cells darker than the surrounding tissue, and thus render them more conspicuous. To ensure sections being well stained, all protoplasm, etc., must be got rid of. This is effected with soda lye, washing with much water (acidified with acetic acid if necessary), and then allowing to drain. Afterwards immerse in a $\frac{1}{2}$ to 1 per cent lukewarm stain solution for two or three minutes, and again wash until the water runs clear.

For double staining, first put sections in the stain affecting the lignified tissue, thickened cell-walls, etc., wash well and transfer to stain for parenchyma. This should be heated to 100 C, and rendered slightly alkaline. Colours which are fast on cotton were found to stain parenchyma, whilst those that dye wool or silk directly stain the thickened cell-walls, etc. Suitable mordants (tannin, acetate of lead, etc.) for fixing the colours must be found by experiment.

Staining Tubercle Bacilli.†—A modification of Fränkel's method consists in dissolving 1 part of fuchsin in 100 parts of a 5 per cent. solution of carbolic acid, adding 10 per cent. of absolute alcohol and heating the fluid in a watch-glass to near the boiling point. Float the cover-glasses in the stain for two minutes, remove, and *immediately* immerse for one minute in a solution of one to two parts methylene blue in 100 parts of 25 per cent. sulphuric acid. Then flood with water, dry, mount in balsam.

Cements for Slides.—The "Gram-Rutzou" composition recommended by Poulsem (*Botanical Micro-Chemistry*) appears to grow in favour. It consists of Canada balsam 50 gm., shellac 50 gm., absolute alcohol 50 gm., and ether 100 gm. When mixed, dis-

* From abstract in *Microscopical Bulletin*, VIII., 6, p. 41.

† *Merck's Bulletin*, Vol. V., 3, p. 168.

solved, and filtered, evaporate over a water-bath to the consistency of thick syrup. Dallinger, in his new book, makes the useful suggestion that cement-rings should be so finished that, when the objects are examined by means of immersion objectives, the rings will be unaffected by the cedar-oil used as immersion fluid. Hollis's liquid glue, or a varnish made by dissolving shellac or good sealing-wax in strong alcohol, will effect the desired purpose when thinly brushed over the edges of the mounts, however closed and finished. The *Scientific American* gives a recipe for a transparent cement composed of dammar 5 drs., mastic 3 drs., hardened Canada balsam 3 drs., chloroform and rectified turpentine each 1 fluid oz. Dissolve and filter.

Biological Water Analysis.*—An instructive note by Geo. W Rafter deals with the microscopical as distinct from the bacterial analysis of water. The former deals with all forms of life that are *easily* studied in all their phases by use of the microscope, including algæ, larger fungi, sponges, infusoria, rotifers, etc. The various forms of apparatus used are figured and described and the technique clearly explained. Special attention is devoted to refinements in enumeration and measurement, and the work is placed on a thoroughly scientific basis.

Identification of Pectic Substances.†—The method recommended by L. Mangin for determining the presence of these substances in plant-tissues is to wash sections with acetic acid (1·5 per cent.); then neutralise and treat with a mixture of naphthaline blue R and acid green. The pectic compounds are stained violet by the former, whilst lignin and suberin fix the green stain. By acting on small pieces of tissue with dilute hydrochloric acid, or a mixture of acid, 1 part, and alcohol, 3 parts, pectic acid, if present, will be separated from the base (usually lime, with which it is combined). It is quite insoluble in water, but may be dissolved by the action of a weak alkali, and then precipitated in gelatinous flakes by a weak acid. Pectose is found associated with the calcium pectate, but is not readily isolated, remaining behind after the action of the alkali.

* *Amer. Mon. Micro. Journ.*, March, 1892.

† *Journ. de Bot.*, Vol. VI., p. 363, in *Pharm. Journ.*

To Stain Wood Black.—A process that is much employed for the above purpose consists in painting the wood consecutively with copper sulphate solution (1 per cent.) and alcoholic aniline acetate (equal parts of alcohol and acetate). A very durable black, and the nearest approach to real ebony, is readily obtained by moistening the surface of the wood with dilute sulphuric acid (1 : 20), and subsequently applying heat. A temperature of 60° to 90° C. suffices in a very few minutes to produce the desired result. An excellent black was obtained in this way on beech, bass, and boxwood; while a second treatment was necessary in the case of cherry, walnut, and birch. With oak and ash the results were not so good; and apple and different varieties of pine were still less amenable to the process, pine especially being unevenly stained. In order to afterwards remove the acid from the wood, it might be well to thoroughly wash the latter with dilute soda solution, followed by clean water. It is unlikely that this method can be applied to any but small articles, because of the risk of possible fractures during the necessary heating of the wood. —*Boston Journal of Chemistry.*

Preservation of Microscopic Specimens.—Tores *(Cent. f. allg. Path u. Path. Anat)* (1896, p. 134) describes a method which he has tested for a year and a-half, of preserving organs and tissues so that they retain the colour they had when fresh. He finds that 5 to 10 parts of a 40 per cent. solution of formalin alone, causes the organs after a time to assume a tint which differs very considerably from the natural colour; but that if instead of water for diluting the commercial formalin solution, a solution of 1 part common salt, 2 parts of magnesium sulphate, 2 parts sodium sulphate, in 100 parts of water be used, the colour of the blood is well preserved. Further, material preserved in such a solution is better adapted for subsequent microscopic examination, since the protoplasm of the cell is less altered, and the nucleus stains better and more deeply.

The method he adopted is as follows: The material must not be too long washed in water, and should be left in the formalin solution for a period depending on their size and thickness. A kidney or spleen requires two days' immersion, and the solution

should be changed once or twice, or until the formalin solution no longer gives a dirty, brownish-red colour. Care must be taken to bring all portions of the object into contact with the solution, and the object must be given the shape which it is to retain permanently, since the formalin solution causes it to assume a consistency such that its shape cannot afterwards be modified. In the formalin solution the organs change colour and become of a dirty, bluish-grey. On now placing them in 95 per cent. alcohol the normal colour returns. Before permanently placing the organ in alcohol it must be washed with alcohol until the latter no longer becomes cloudy. The material must not be washed with water. The material is left in alcohol for a varying time until the normal colour has again fully returned; if left longer the alcohol removes the colour. For a kidney or spleen twenty-four hours is sufficient. The permanent preserving fluid is equal parts of glycerine and water; the material floats at first, but sinks later; the colour is now at its best; after a little time the fluid becomes yellowish and requires renewal. Tissues so preserved have not undergone the slightest alterations in colour during nine months. The method is not applicable to the preservation of any other colour than that of blood—thus, icteric liver is not well shown.—*British Medical Journal*, June 20th, 1896; Epit., p. 100.

Glycerine Jelly, made by Gage's formula, is said to be clear and bright:—Let gelatine, 25 gm., stand in enough distilled water to cover it until softened, then pour off excess of water, and heat gelatine till dissolved. (*Mem.*, As the quantity of water taken up varies with the time, it is usually better to add four times the weight of the gelatine taken.) Next add white of egg, 5 c.c., to the melted gelatine, stir thoroughly, and heat till the albumin coagulates. Filter while hot; then add chloral hydrate, 5 gm., and as much glycerine as the gelatine solution measures. Again heat gently and filter. The jelly is then ready for use.—*Pharmaceutical Journal.*

Reviews.

A TEXT-BOOK OF BACTERIOLOGY, including the Etiology and Prevention of INFECTIOUS DISEASES, and a short account of Yeasts and Moulds, Hæmatozoa, and Psorosperms. By Edgar M. Crookshank, M.B., etc. Fourth edition, reconstructed, revised, and greatly enlarged. 8vo, pp. xxx.—715. (London: H. K. Lewis. 1896.) Price 21/- nett.

This, though nominally a fourth edition, is practically a new work. The progress of Bacteriology has been very rapid, and many new investigations having been made in connection with the etiology, prevention, and treatment of communicable diseases, the author has found it necessary to reconstruct, enlarge, and thoroughly revise the text and to add twenty-six new chapters.

The book is divided into three parts. Part I. is mainly technical, and includes the most recent methods employed in studying bacteria and in investigating the etiology of disease. Part II. deals with infectious diseases and the bacteria associated with them; in this part the most effectual measures for stamping out these diseases are referred to. Part III. contains descriptions of about five hundred bacteria. There are 273 illustrations in the text, many of which are printed in colours, and 22 beautifully-coloured plates. The student of bacteriology will find it a most valuable book.

SECTION CUTTING AND STAINING: A Practical Introduction to Histological Methods for Students and Practitioners. By W. S. Colman, M.D., M.R.C.P. Second edition. Cr. 8vo, pp. viii.—160. (London: W. K. Lewis. 1896.) Price 3/6.

Histologists and microscopists generally will find a large amount of useful information here. The nine chapters treat of Apparatus, Hardening Processes, Section Cutting and Mounting, General and Special Methods of Staining, Injection of Blood Vessels, and Directions for Preparing Individual Tissues.

AN INTRODUCTION TO STRUCTURAL BOTANY. Part II., Flowerless Plants. By Dukinfield Henry Scott M.A., Ph.D., F.R.S., F.L.S., F.G.S., etc. Cr. 8vo, pp. xv.—312. (London: A. & C. Black. 1896.) 3/6.

Whilst it was possible to give an idea of the main outlines of structure in Flowering Plants in Vol. I. by a full description of three representatives, it has been found necessary to select no less than twenty-three types for illustration of the Cryptogams.

The essential morphological points have been well brought out. There are 114 illustrations and a good index.

A VEST-POCKET MEDICAL DICTIONARY, embracing those Terms and Abbreviations which are commonly found in the Medical Literature of the day, but excluding the names of Drugs and Anatomical Terms. By Albert H. Bush, M.D. Size, 2¼ by 3½ by ½ in.; pp. 529. (London: Bailliere, Tindall, and Cox. 1897.) Price 3/-

Owing to the large number of new words which have been introduced into medical terminology during the last ten years, and the changes in signification which have taken place in a few of the older terms, it has been found necessary that such a book as the one now before us should be published. Although the paper on which it is printed is exceedingly thin, as will be inferred from 530 pages only occupying the space of half an inch, the type is thoroughly distinct. The book is nicely bound in morocco, and is sure to prove a most useful pocket companion.

HANDBOOK OF PHYSIOLOGY. By W. D. Halliburton, M.D., F.R.S. 14th edit. 8vo, pp. xviii.—851. (London: J. Murray. 1896.) 14/-

This (fourteenth) edition is practically a new work, for the subject matter has been re-arranged and almost entirely re-written. It is a work intended for the use of medical students, and one of its special features is that it treats of Histology as well as Physiology proper.

The book contains 57 chapters of closely printed matter, every subject being handled in a thorough and masterly manner. There are upwards of 660 illustrations in the text, several of them coloured, besides some plain and coloured plates.

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ELEMENTS OF PSYCHOLOGY. By George Croom Robertson. Edited from *Notes of Lectures delivered at the College* 1870—1892, by C. A. Foley Rhys Davids, M.A. Crown 8vo, pp. xvi.—268. (London: J. Murray, 1896.) Price 3/6.

This work consists of a series of 36 Lectures, most of which were delivered orally by the late Grote Professor Robertson at University College, London. The editor says, in her introduction:—"I have tried to make students of a succeeding generation acquainted with the methods of a great methodologist, and with the philosophic standpoints of a teacher who for many years worthily represented and further developed the best traditions of a great school."

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ECONOMIC SCIENCE AND PRACTICE; or, Essays on Various Aspects of the Relations of Economic Science to Practical Affairs. By L. L. Price. Cr. 8vo, pp. viii.—325. (London: Methuen and Co. 1896.) 6/-

This book consists of thirteen papers, which have been written at various times and for different occasions; they deal generally with the relations of economic theory to proposals of practical economic reform. In the first, entitled "Some Typical Fallacies of Social Reformers," an attempt is made to set forth the moral, if it may be so called, of the present position. In the six following essays different aspects of various methods of industrial reform, which have lately engaged a large measure of popular attention, are brought under review.

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THE TUTORIAL CHEMISTRY. Part I., Non-Metals. By G. H. Bailey, D.Sc.Lond., Ph.D.Heidelberg. Edited by William Briggs, M.A., F.C.S., F.R.A.S. Cr. 8vo, pp. viii.—226. (London: W. B. Clive.) 3/6.

Here we have a systematic outline of Chemistry so far as it relates to the non-metals. Details of experimental methods are given, which, under the guidance of the teacher, will be found sufficient to admit of the book being used as a companion in the laboratory. Each chapter is followed by questions, the more difficult of which are answered at the end of the book. There are a number of illustrations.

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A NEW COURSE OF EXPERIMENTAL CHEMISTRY, including the Principles of Qualitative and Quantitative Analysis, being a Systematic Series of Experiments and Problems for the Laboratory and Class-room. By John Castell-Evans, F.I.C., etc. Cr. 8vo, pp. xii.—244. (London: Thomas Murby.) Price 2/6.

In the present revised edition of this work, the author's aim is to help students to attain a real knowledge of scientific chemistry, and not to prepare for mere examination, for, as he justly says in his preface, "Examinations are only accidents of a scientific career, and accidents that are rarely beneficial; but *knowledge* is essential."

We feel that we can confidently recommend the book.

THE SURVIVAL OF THE UNLIKE: A Collection of Evolution Essays suggested by the Study of Domestic Plants. By L. H. Bailey. Cr. 8vo, pp. 515. (London: Macmillan and Co. 1896.) Price 8/6.

The author, a botanist of some considerable repute at the Cornell University (U.S.A.), has in these essays desired to answer many of the common questions which puzzle horticulturists by appealing to the evidence of evolution. He desires to spread a knowledge of the evolution speculations, and the methods of research which they suggest, amongst those who deal with plants and animals and who lead a rural life.

The book contains 30 essays, divided into three sections:—I., Essays teaching the General Fact and Philosophy of Evolution; II., Essays expounding the Fact and Causes of Variation; and III., Essays tracing the Evolution of Particular Types of Plants. The essays are very ably written.

CHARLES DARWIN, and the Theory of Natural Selection. By Edward B. Poulton, M.A., F.R.S., F.G.S., F.L.S., etc. Cr. 8vo, pp. 224. (London: Cassell and Co. 1896.)

In this interesting little volume the author gives us what he believes to be the most important statements of this great scientist, while he has grouped them in such a manner as to present a connected account of Darwin's life, when considered in relation to his marvellous work, and especially to the great central discovery of Natural Selection, and its exposition in the "Origin of Species."

SCIENCE PROGRESS: A Quarterly Review of Current Scientific Investigation. New series. Vol. I., No. 1, Oct., 1896. Price 3/-; subscription price 10/6 per annum post free. (London: The Scientific Press, Ltd.)

The part before us commences a new series of this thoroughly up-to-date journal. This part contains papers on the following subjects:—Scientific Weather Forecasting, by G. J. Symons, F.R.S.; The Natural History of Igneous Rocks, by Alfred Harker, M.A.; Recent Work upon Visceral and Allied Nerves, by T. Gregor Brodie, M.D.; Notes on Parasites, Part I., by A. E. Shipley, M.A.; Teratology in Modern Botany, by K. Goebel, Ph.D.; The Nervous System of Cœlentera, by S. J. Hickson, F.R.S.; Palæontology and Evolution, by A. C. Seward, M.A.; and Appendixes, Notices of Books.

A NEW ENGLISH DICTIONARY on Historical Principles. Edited by Dr. James A. H. Murray. DISBURDENED—DISOBSERVANT, Vol. III.; and FISH—FLEXUOSE, Vol. IV. Price 2/6 each part.

We notice that the first of these sections contains 1396 main words, 27 combinations explained under these, and 127 subordinate words, or 1550 in all. Of these 1450 words are illustrated by 6990 quotations. Perhaps the most interesting word to be found in these pages is DISMAL, the full history of which is here for the first time exhibited. Contemporary evidence shows this to have been originally the Anglo-French *dis mal*; Latin, *dies mali*, evil or ill-omened days, the "Egyptian days" of the mediæval calendar; and it was so applied for more than three centuries. It is only as we come down to 1600 that we find other things than days characterised as "dismal."

The Vol. IV. section contains 956 main words, 314 combinations explained under these, and 170 subordinate entries, making 1440 in all. The *obvious combinations*, recorded and illustrated by quotations, without individual definition, number 372 more.

Of the 1812 words contained in this section, not more than 35 existed in Old English. The most striking characteristic of this portion of the English

vocabulary is the abundance of words which have been influenced in their sense-development by their apparently imitative or expressive sound, as *fizz*, *fizzle*, *flabbergast*, *flack*, etc. etc. The etymological notes on most of these words will be found to contain facts not given in other English dictionaries.

The editors are to be congratulated on the very efficient manner in which they are performing their very arduous work.

THE POCKET ATLAS OF THE WORLD. By J. G. Bartholomew, F.R.C.S., F.R.S.E., etc. Tenth edition. Size, $3\frac{1}{4}$ by $4\frac{3}{4}$ by 1 in. (London: John Walker and Co. 1897.) Price 2/6 in cloth; 3/6 leather binding.

The tenth edition of this useful little atlas has been greatly amplified and extended. Without increasing the bulk, 72 new plates have been added, the text has been re-written, and the maps thoroughly revised to date. The Index to the maps occupy 72 double-column pages.

KNOWLEDGE IN A NUTSHELL. Size, $2\frac{1}{4}$ by $3\frac{1}{2}$ by $1\frac{3}{8}$ in. Glasgow: David Bryce and Son.) Price 2/3.

Undoubtedly the book before us is all that its name implies. First, we have BRYCE'S PEARL ENGLISH DICTIONARY, comprising, besides the ordinary and newest words in the language, short explanations of a large number of Scientific, Philosophical, Literary, and Technical Terms, occupying 384 pages. BRYCE'S PEARL ATLAS OF THE WORLD, containing 72 maps. BRYCE'S PEARL GAZETTEER OF THE WORLD, comprising the most recent statistical information and notices of the most important historical events associated with the places named, also the last census, occupying 438 pages; and lastly, THE DESK PROMOTER, affording information in daily requisition, and an Index, covering 120 pages. This is altogether a very useful book.

ECONOMIC ENTOMOLOGY for the Farmer and Fruit-grower and for use as a Text-book in Agricultural Schools and Colleges. By John B. Smith, Sc.D. 8vo, pp. 481. (Philadelphia, U.S.A.: J. B. Lippincott Co. 1896.) Price $2.50 (10/6).

Insect injury to agricultural products amounts each year to a very considerable sum, and as a whole shows a tendency to increase rather than otherwise. Progressive farmers have long been aware of this, and the science of economic entomology has grown up in response to their demands for information concerning insect depredation and for means of protection against it. In this book an attempt is made to present these matters so completely as to give a foundation upon which further information may be added.

The book—which, we trust, will be the means of saving a large amount of agricultural produce, not only in the United States, for which it is written, but in this country also—is divided into three parts. The first is devoted to the Structure and Classification of Insects; the second treats of the Insect World; and the third of Insecticides, Preventives, and Machinery. There are 483 very good illustrations.

AGES AGO: The Ancestry of Animals. By Edith Carrington. Post 8vo, pp. 179. (London: G. Bell and Sons. 1896.) Price 1/-

This is one of the very interesting series of Animal Life Readers, its object being to give to young people a first idea of the great antiquity of animal life on the earth, and to show the essential part that animals have played in the history of the world in its various stages of development. It is nicely illustrated by Harrison Weir and others.

HALF-HOURS IN THE TINY WORLD: Wonders of Insect Life. Cr. 8vo, pp. xii.—308. (London: Jas. Nisbet and Co. 1896.) Price 2/6.

A very interesting and nicely illustrated little book, containing a series of chapters describing Insect Life, Caterpillars, The Spider and its Web, Bees and Beehives, Wasps and Paper-making, Silk and Silkworms, Flies, Ants and Ant-hills, Life in a drop of Water, Coral and Coral-builders, Nature and her tools, etc. There are 80 or more good illustrations.

GLEANINGS FROM THE NATURAL HISTORY OF THE ANCIENTS. By Rev. W. G. Watkins, M.A. Cr. 8vo, pp. xv.—258. (London: Elliot Stock. 1896.)

In this exceedingly interesting book we have a number of chapterson a few of the curiosities connected with the natural history of the ancients; they have been put together with much trouble and not a little honest, diligent research; the object of the author being to collect some of the more interesting facts bearing upon ten or a dozen different subjects rather than to write a complete natural history of the ancients. These chapters treat of Greek and Roman Dogs; Antiquarian Notes on British Dogs; the Cat; Owls; Pygmies; Elephants; the Horse; Gardens; Hunting among the Ancients; the Romans as Acclimatisers in Britain; Virgil as an Ornithologist; Roses; Wolves; Ancient Fish-lore; Mythical Animals; and Oysters and Pearls.

NATURAL HISTORY PICTURES for Object Lessons. Size of Plates, 24 by 28 inches. (Edinburgh: W. and A. K. Johnston.) Price, 3/6 each.

A series of beautiful plates printed in colours. Those sent to us illustrate and thoroughly describe The Flamingo, Anemones, and Corals; the Tiger, Serpents, and the Whale—*e.g.*, The Anemones and Corals are thus described:—*Anemones*, sub. Kingdom *Cœlenterata*, Class *Actinozoa*, Order *Zoantharia*, Anémones (French); Anémones (Spanish); Windroschen (German). Then follows a full description. Those represented on this sheet are: 1, The Actinoloba Dianthus; 2, Bolocera Eques; 3, Sagartia Veduata; 4, Cereus Coriaceus; 5, Anemonia Cereus Alcyonaria. CORALS: Sub-Kingdom, *Cœlenterata;* Class, *Anthozoa;* Order, *Alcyornaria;* Corails (French) Corales (Spanish); Koralle (German). Those represented being Corallium Rubrum or Red Coral, and of the Madrepore Danœ.

The other sheets are equally well described. These sheets are splendidly suitable for schoolroom walls.

WONDERLAND; or, Curiosities of Nature and Art. By Wood Smith. Cr. 4to, pp. 288. (London: Thomas Nelson and Son. 1897.) 3/6.

A charming book for young people. Wonderland consists of two great regions, one called Nature, the other Art, in each of which there are many marvellous things, all of which are described in a most interesting manner, and very beautifully and profusely illustrated, there being no fewer than 170 illustrations. Many of them are full-page plates.

SIMPLE LESSONS FROM NATURE. By M. Cordelia E. Leigh. Post 8vo, pp. xii.—131. (London: J. Nisbet.) Price 1/-

We have here a series of very simple lessons drawn from Nature for young children, the aim of the author having been to make them as simple as possible. The facts to which they refer when carefully explained can hardly fail to increase the love and reverence of scholars for their Maker, while the interest excited may develop their power of observation and research, and afford useful employment for their time and thought.

Entomological Notes for the Young Collector. By W. A. Morley. 12mo, pp. x.—129. (London: E. Stock. 1896.) Price 2/-

Young collectors will find this just the book they require. Its twelve chapters tell what butterflies and moths may be caught each month, with hints as to apparatus, setting, etc. etc.

We are sorry to note that, in common with many other entomologists, the author apparently ignores generic names, and gives only their initials.

Out-of-the-Way Pets and other Papers. By Rev. Theodore Wood, F.E.S., etc. Cr. 4to, pp. 263. (London: F. Sherlock.) Price 5/-

This very nice little book consists, first, of a series of twenty-four papers, originally published in the *Church Monthly*, describing a variety of animals, birds, insects, etc., followed by a series of twelve monthly rambles. In most of these the author has endeavoured to emphasise the great lesson that what men mostly call Nature is a second Bible. There are upwards of 70 good illustrations.

Across Greenland's Ice-Fields: The Adventures of Nansen and Peary on the Great Ice-Cap. By M. Douglas. Crown 8vo, pp. 218. (London: Thos. Nelson and Son. 1897.) Price 2/-

The author of this interesting and nicely illustrated little book has selected those heart-stirring narratives for her theme which relate to the perils and difficulties attendant on the exploration of the Inland Ice of Greenland. Miss Douglas conducts her readers over those trackless wastes of snow and ice in the footsteps of Nordenskiöld, of Nansen, and of Peary; and certainly those who begin the journey with her will, in continuing it to the end, derive no small amount of pleasure and instruction. A portrait of Nansen forms the frontispiece to the book.

On the Broads. By Anna Bowman Dodd. Fscap. 4to, pp. xii.—331. (London: Macmillan and Co. 1896.) Price 10/6.

A most interesting and pleasantly written book describing a fortnight's cruise on the Broads, the district which lies between the sea-beaches of Yarmouth and Lowestoft. "For more than a decade," says the author, "cruising on the Broads has taken a foremost place in the long list of summer sports and pastimes yielded by that amazing little island, where, by utilising every rill and rivulet, every hill and upland, man has doubled the size and tripled the pleasure-giving capacity of the stretch of land he calls England." There are 30 fine full-page illustrations.

The Story of Extinct Civilisations of the East. By Robert E. Anderson, M.A., F.A.S., etc. Fscap. 8vo, pp. 229. (London: George Newnes, Ltd. 1896.) Price 1/-

This is one of the Interesting Story Series, and tells us in very readable language of—1, The Origin and Races of Mankind; 2, Chaldea and Babylonia; 3, Ancient Egypt; 4, Hittites, Phœnicians, and Hebrews; 5, The Arab; and 6, Iran, or Ancient Persia. There is an illustration of the Moabite Stone; Hieroglyph; Cuneiform Inscription; and maps of Egypt, Khita, and Spain.

Bromide Paper: Instructions for Contact Printing and Enlarging. By Dr. A. E. Just. 4th edition. 8vo, pp. 144. (London and Bradford: Percy Lund. 1896.) Price 1/6.

Very full instructions are here given for every detail of the work from the Preservation and Cutting and Handling of the Paper, Exposing, Lighting, to Enlarging. A number of Formulæ are given.

Everyone's Guide to Photography, containing Instructions for making your own Appliances and Simple Practical Directions for every branch of Photographic Work. By E. J. Wall, F.R.P.S., etc. 16mo, pp. 246. (London: Henry J. Drane.) Price 6d.

A capital and most useful little book, quite answering to its title. Besides going thoroughly into the subject of Photography generally, it has chapters on Pinhole and Stereoscopic Photography, Hand and Detective Cameras, Photography in Natural Colours, Iron and Uranium Printing, The New Photography, Ghosts, Freaks, and other Photographic Effects, etc. etc. The size, 5½ by 4 in., makes it convenient for carrying in the pocket.

Everyone's Housekeeping Companion. 16mo, pp. 250.

Everyone His Own Doctor; or, The Household Medical Guide. Edited by Alexander Ambrose, B.A., LL.D., M.D., etc., etc. 16mo, pp. 254.

How to Speak Well in Public or in Private. By Charles Hartley; 16mo, pp. 176. (London: Henry J. Drane.) Price, cloth, 6d. each; leather, 1/-

The Housekeeping Companion contains a large number of hints for all kinds of Cooking, Preserving, and Pickling. The Making and Keeping of Home-made Wines and Temperance Drinks. A large number of useful and valuable Household Recipes, and full directions for Carving, the latter being well illustrated.

The second of these little books presents in a popular form some of the latest knowledge of those subjects which are of every-day medical interest; it is arranged in Dictionary or Cyclopædic form, so that everything is easily found.

In How to Speak Well some very good hints are given on Elocution and Oratory, which may be profitably read by many.

The whole form a useful set of little books.

The Dark-Room and its Equipment. By H. J. L. J. Masse.

Lantern Slides: Their Production and Use. By J. Pike.

Developers: Their Use and Abuse. By Richard Penlake.

The Camera and its Appurtenances. By H. J. L. J. Masse.

The ABC of Re-touching. By Andrew Young.

Photography and Architecture: How each lends interest to the other. By E. MacDowel Cosgrave.

Indoor Photography and Flash-Light Studies of Child Subjects. By Bertha M. Lothrop.

The X Rays. By Arthur Thornton, M.A.

(Bradford and London: Percy Lund and Co. 1896.) Price 6d. each.

The above little books—together with the two we noticed in our October issue (Drop-Shutter Photography and the Elements of Stereoscopic Photography)—form, we believe, the entire series, so far as published, of Mr. Percy Lund's Popular Photographic Series. They form a valuable and very compact library of photographic works. The size of the books, being 7½ by 4 in., makes them very convenient for carrying in the breast-pocket.

These little books are carefully written, the instructions given being concise and clear. They are printed on good paper and well illustrated; indeed, illustration appears to be one of Mr. Lund's strong points.

CASSELL'S DICTIONARY OF COOKERY. Roy. 8vo, pp. xcvi.—1178. (London: Cassell and Co. 1896.)

We are told in the Preface that "Life is made all the brighter by satisfactory feeding, and he is a dull philosopher who despises a good dinner. . . . But the strong point of good cookery is not the gratification of the palate, but its influence on health. . . . Our household would enjoy better health, and be better able to withstand sickness when it came, if pains were only taken to have food well chosen and properly made ready. A desire to aid in the diffusion of knowledge on such an important topic induced the publishers to project a Work on Cookery, which would be at once the largest and most complete collection of recipes ever produced in this country." Arranged in Dictionary form we find here about *nine thousand* recipes, which have been put in the simplest form, and the plainest language. The first 90 odd pages treat of the Principles of Cookery and Table Management; there is also an appendix dealing with Kitchen Utensils, Seasonable Food, and Glossary of Terms used in Cookery. We need only add that the book is now in its one hundred and thirty-fifth thousand to show how well it has been received.

THE BRITISH AND COLONIAL DRUGGIST'S DIARY, 1896.

As usual, this diary contains a large amount of information of much use to the druggist, amongst which we particularly notice "Notes on Food Analysis" and X Rays for Chemists. The diary, interleaved with blotting paper, will be found particularly serviceable.

THE STANDARD PRICED CATALOGUE of the Postage and Telegraph Stamps and Postmarks of the United Kingdom, No. 5. Compiled and published by H. L'Estrange Ewen. Post 8vo, pp. 218. (Norwood: 32 Palace Square. 1896.) Price 2/6, post free.

Stamp collectors, and particularly those who make a speciality of British stamps, will do well to secure a copy of this catalogue. Mr. L'Estrange Ewen is a specialist, and gives such information in this catalogue as is not to be found, so far as our experience goes (and it is somewhat considerable), in any other work on the subject.

The scope of the book is so well explained in the title that we think it unnecessary further to describe the book.

THE LINCOLN STAMP ALBUM, with Catalogue and Maps. Eleventh thousand. Crown 4to. (London: W. S. Lincoln, 2 Holles St., Oxford St.) Price 5/-

Spaces are provided in this catalogue for 6,500 stamps, special spaces being provided for stamps of unusual shape and size. The ruled pages are headed with the names of countries arranged in geographical order, and in the catalogue at end many interesting particulars are given; there are also 16 maps. The album is very suitable for a beginner.

MORING'S QUARTERLY for October (Thos. Moring, 52 High Holborn, W.C.) contains an interesting article on Methods of Reproduction for Book Illustrations.

A Chapter on Light and Colour.

By G. H. Bryan, Sc.D.

1.—Elementary Phenomena of Light.

THE agent which affects the sense of sight is spoken of as LIGHT. It has been conceived of as small particles emitted from visible bodies and striking the eye, or as a wave motion propagated through a medium (called the ETHER) and exciting the nerves of the retina by this motion. The latter view has now come to be accepted to the complete exclusion of the former, though such eminent names as those of Newton, Laplace, and Biot are connected with the development of the CORPUSCULAR THEORY OF LIGHT.

The most striking of simple light phenomena, the production of shadows, and the sharpness of the shadows when the source of light is nearly a point, was for a long time a great difficulty in the way of the acceptance of the UNDULATORY THEORY, but this difficulty has been overcome, and the simplicity of the explanation, afforded by this theory, of many somewhat complex phenomena, has placed it in complete command of the field. The vibrations which produce light are transverse to the direction of propagation.

2.—The explanation of many facts can be obtained by an application of four simple laws of light propagation.

(i.) Light is transmitted in straight lines.

(ii.) When a ray of light is reflected, the reflected ray makes with the reflecting surface an angle equal to that made by the incident ray, and the two rays are in a plane perpendicular to the surface.

(iii.) When a ray of light is refracted at the surface of two different media, the angles of incidence and refraction have a determinate relation to one another depending on the media, and the plane of the two rays is perpendicular to the refracting surface. The relation referred to is that the sines of the angles of incidence and refraction are in a constant ratio.

(iv.) If a ray be reversed at any point of its path, it will return over exactly the same path as that which it has already traversed. A RAY is here conceived of as the smallest portion of light which can be separately transmitted, reflected and refracted. A group or bundle of rays constitutes a PENCIL.

3.—The first of the above laws is sufficiently obvious, but we shall see that light, like sound, can bend round a corner, though not sufficiently, in general, to produce effects readily recognisable.

The production of IMAGES BY REFLECTION in plane, and even in curved, mirrors is familiar to us also. The image is as far behind a plane mirror as the object is in front of it. Curved mirrors produce images not, in general, equal in size to the object, and may produce curiously contorted images.

The REFRACTION or bending of rays of light as they pass from air to water or glass causes a change in the appearance of an object seen through such bodies, unless a second bending takes place at a parallel surface to recompense for the first. The production of images by lenses is a practical application of this bending of light by glass, and in telescopes, microscopes, opera-glasses, and spectacles is made of great service to mankind. The position, size, and degree of distortion (if any) of the image, can be determined by repeated calculations from the laws given above.

Refraction is closely connected with TOTAL REFLECTION. Contrary to what is usually the case, at angles of incidence beyond a certain limit, light traversing a denser medium and meeting a surface of separation from a less dense, is no longer divided into both reflected and refracted waves, but gives only the former, being, for all angles of incidence exceeding this limit, *totally reflected* into the medium which it is traversing.

If light be propagated through a medium which is not homogeneous, its path will not be a straight line. The light from the stars suffers a continuous bending in passing through the earth's atmosphere. In some tropical regions the sun's heat causes a state of the atmosphere to be set up in which layers of differently-heated, and therefore differently-refracting, air are superposed in such a way as to totally reflect rays of light which were originally travelling at a small upward inclination. In this way the phenomenon of MIRAGE is produced.

4.—If a source of light, such as a candle flame, be placed behind a pinhole in a card, an image of the light giving body may be obtained by interposing a screen in the path of the light which passes through the hole. The image is found to be inverted, and if a sensitised plate be substituted for the screen, a fairly well developed photograph may be obtained of any object placed in front of the pinhole. Other holes will give other images, and by the continued multiplication of holes the individuality of the images may be destroyed and a tolerably uniform illumination of the screen, within the shadow of what remains of the card, results, due to the overlapping of each image by its immediate neighbours on all sides. Unless the source of light be quite small, the shadow of an opaque object or the light transmitted through a hole will not be terminated by a sharp edge.

The light gradually becomes fainter as we approach those regions which are so placed as to receive light from a part only of a luminous body. This partially bright border is called the PENUMBRA, and its consideration is of great importance in the calculation of the circumstances of eclipses.

5.—The fact that light is not instantaneously transmitted from point to point was proved by Roemer in 1676 from a consideration of the eclipses of Jupiter's moons, which appear to take place earlier or later than predicted, according as the earth is at the part of its orbit nearest to, or furthest from, Jupiter. The range of eight minutes on either side of the average in the time at which these eclipses are seen is due to the extra distance, equal to the diameter of the earth's orbit, which the light has to traverse in the one case compared with the other.

In 1725 Bradley showed that a small displacement of the apparent positions of stars was due to the fact that the velocity of light is only about 10,000 times that of the earth in its orbit. The ABERRATION is a phenomenon exactly analogous to the apparent slope of rain drops, really falling vertically, as seen from a swiftly moving train. From Bradley's observations, and a knowledge of the sun's distance otherwise gained, the velocity of propagation of light could be determined.

6.—This determination, however, was made directly by Fizeau in 1849 by the use of a rapidly revolving toothed wheel. It was

found to be possible to rotate the wheel so fast that light which, emerging between two of its teeth, passed on to be reflected back from a mirror five miles distant, returned to the wheel to find its path blocked by a tooth. A more rapid rotation permitted it to pass through the next gap. Knowledge of the distance traversed by the light and the speed of rotation of the wheel enabled the speed of light to be calculated. Another method, due to Foucault, was devised about the same time, which involved the use of a rapidly revolving mirror. The distances used were in this case shorter by far than in Fizeau's method.

By the application and perfection of these methods, the VELOCITY OF LIGHT has been found to be about 186,400 miles per sec. The length of an undulation is extremely small, however, being only about 1/40,000th of an inch, so that about 500,000,000,000,000 of waves are received into the eye in each second.

7.—**Colours.**—When light is refracted through a wedge-shaped piece of glass, known as a PRISM, it is found that, instead of a single image of the luminous object, a coloured band of greater or less length is obtained. The various colours may be recombined in various ways, and are found to give, as a result, simple white light. The spreading out of light in this way is called DISPERSION, and the power of producing it varies in different transparent substances. It affords evidence that white light is not simple, but complex, and that the variously coloured beams which go to make up a beam of white light are refracted by slightly different amounts in the same refracting medium.

The coloured band, if the dispersion be great enough, is found to contain the colours in the order, red, orange, yellow, green, blue, indigo, violet. The red end is the least refracted, the violet end the most. The coloured band is called a SPECTRUM.

8.—The mixing of various colours produces on the eye the effect of some other simple colour tint, but the SPECTROSCOPE at once shews that the colour seen is a mixture, not a pure colour. It has been maintained that suitable combinations of vermilion, emerald green, and ultramarine properly chosen can be made to give any desired colour sensation. Others maintain the necessity for five primary colours. The mixture of colours and the mixture of the

pigments of certain colours are, however, entirely different means of producing colour.

In the former case a compound sensation is produced indistinguishable from some other simple sensation. The latter effect is due to absorption. Certain substances possess the property, either when in solution, or when used to tint glass, of stopping a part of the light which falls on them, while leaving the greater part of it unaffected. Their colour, as seen by transmitted light, is the effect of the light not absorbed by them.

If two such absorbent bodies act successively on white light, they may abstract nearly all the colours from that light—in fact, they may even abstract all, in certain cases. If a yellow and a blue be used, the one colour not absorbed largely by either is green, and hence the combination of yellow and blue pigments produces a green pigment, while the combination of a pure yellow and a pure blue light *may* produce a pinkish colour.

9.—The colours of the spectrum are, both as to their nature and as to order, those shewn by the RAINBOW. When sunlight falls on the drops of water forming a cloud, it is partly refracted into those drops. If it emerge after reflection at the back of the drop, there is one particular direction in which the light is greatly condensed. This direction varies slightly for different colours, and hence the drops which send light to the eye in this direction give the appearance of a coloured band, red on the upper side, violet on the lower. Outside the bow there is complete absence of light reflected from the drops.

After two or more internal reflections the light may emerge in sufficient strength to produce other bows. The secondary bow is frequently seen. It is larger than the primary, and the colours are in the reverse order. The tertiary and quaternary bows are on the same side of the observer as the sun and are drowned in his light. The bows of higher orders are too faint to be visible.

Curious effects of *Halos*, *Parhelia*, etc., are produced when ice-crystals take the place of raindrops in the cloud.

10.—The perfecting of the means of obtaining a spectrum, by using a slit as source of light, as Wollaston did in 1802, revealed the fact that the spectrum was not continuous, but crossed by dark bands, indicating a deficiency of certain kinds of light. Fraun-

hofer in 1817 rediscovered these bands independently, and, using a narrower slit, was able to map their positions. The chief of them are still known by the letters A, B, C, etc.; a, b, c., etc., by which Fraunhofer referred to them. It was found that if the light of the sun were made to pass through the light of the electric arc coloured yellow by sodium, the dark line (or pair of lines) D was marked much more plainly than in the simple solar spectrum.

The arc tinged with sodium alone gave a bright pair of D lines. These discoveries were made in 1849 by Foucault.

11.—The origin of these DARK LINES in the sun's spectrum was not discovered till much later. About 1850, Stokes explained the phenomenon by an analogy from sound.

We know that a tuning fork will, when sounded, excite another fork of the same pitch, without touching it, and such a fork will select from a composite sound the vibrations which it can itself give out when sounded, thereby weakening that particular tone of the composite sound. Similarly, bodies capable of vibrating at such a rate as to emit light of a particular refrangibility will absorb just that same kind of light from the radiations of a composite character which fall on them. The absorbing body emits more than it absorbs if its temperature is above that of the source of light which falls on it; but if below that temperature it absorbs more than it emits, and causes a deficiency in light of that particular kind.

12.—The spectra of different bodies are found to be characteristic of those bodies, and are one of the most delicate tests of their presence. The researches of Kirchhoff and Bunsen in 1860 led to the establishment of the law mentioned above referring to the modification of light when passed through an absorbing medium, and also to the laying down of the principles that

(i.) Incandescent solids and liquids (and, it has since been found, highly compressed gases) give rise to a continuous spectrum.

(ii.) Gases under moderate pressure give spectra of bright lines and bands separated by dark spaces.

The principles thus enunciated enable observers to detect the presence of many well-known bodies, such as iron, magnesium, sodium, and hydrogen, in the sun and many stars and nebulæ. The element helium, not discovered on the earth till a couple of

years ago, manifested its presence in celestial bodies in a similar manner, and its existence in the sun has long been known.

13.—Bodies which are not self-luminous owe their visibility to the SCATTERING of the light which falls on them, due to the extreme irregularity of their surfaces. If they consist of material so disposed as to reflect the incident light without considerable selective absorption in the surface layers, as do snow, powdered glass, etc., they appear of a more or less pure white. If the surface layers are strongly absorptive, the scattered light is deficient in particular colours, and the apparent colour of the body is complementary to the colours absorbed. The light of the moon and planets was believed for various reasons to be simply reflected sunlight, and this conclusion is strongly confirmed by spectroscopic examination of these bodies.

14.—**Diffraction and Interference.**—The light from a luminous point spreads uniformly in all directions in an *isotropic* medium, and hence its brightness falls off in the same proportion as the intensity of a sound, *i.e.*, in the ratio in which the square of the distance traversed increases. If we consider the form of the wave-front at any time, it will be the surface of a sphere. At any subsequent time the disturbance at any point of space may be calculated, either by reference to the original source, or to the wave-front referred to. Each point of this wave-front may be considered as the origin of a disturbance, and, by adding the effects of these disturbances, the total effect at any desired point may be determined. It is found that the effect due to any small portion of the wave-front is evanescent, except in the neighbourhood of the direction perpendicular to the front of the wave, and thus the existence of rays is accounted for. This practical annihilation of one effect by another may best be studied by beginning with a simple case.

In all interference phenomena, the length of the wave of the particular kind of light considered is most important. It is the difference of wave-length of different colours which is the cause of their different refraction, and consequently of the dispersion produced by a prism, and the phenomena of interference are to a large extent masked by the overlapping of the effects due to differently coloured rays, resulting in a practical uniformity of

illumination where homogeneous light would produce contrasts of light and shade.

15.—To study the effect of the mixture of light from two exactly similar sources, the light from a single source, as nearly as possible a point, may be either reflected from two mirrors inclined very slightly to one another, or refracted through a double prism (called a *biprism*) of very small angle. The two images in either case serve as the two similar sources of light.

If the light so reflected or refracted be received on a suitable screen, the illumination is found not to be uniform. The centre of the screen is brightly illuminated from each souree of light, but in passing to one side, we reach a point where the light from one source is half a wave-length behind that from the other, and consequently in a condition to extinguish the effect of the first. Hence a dark line is found at this place. Further on the difference of path is a whole wave-length, and a bright band results, followed by other dark and bright bands alternately.

If the source of light be monochromatic, the alternations of light and darkness can be well observed for some distance. By measuring the breadth of the intervals between the bands, and the distance of the screen from the source of light, the wave-length of the light employed can be calculated. The scale of the effect is larger for red than for blue or violet light, the breadth of the bands gradually diminishing with the wave-length of the light as we pass from red to violet. If white light be used, these differences soon cause the contrasts to lose their sharpness, as the bright bands of some colours fall on the dark bands of other colours at a very slight distance from the centre of the screen.

16.—We see thus that the addition of light to light may produce darkness, and we may hence expect that the subtraction of some part of the illumination due to a point of light may increase the intensity of the brightness at some points in space. This expectation can be proved to be well-founded.

By interposing an obstacle with a straight edge in the path of the light falling on a screen from a luminous point, the effects within the boundary of the geometrical shadow shew this strange effect. The brightness outside the shadow does not abruptly cease at its edge, but is succeeded by a series of alternations of bright-

ness and darkness, some of the former exceeding in intensity the uniform illumination outside the shadow. There are also bands outside the geometrical shadow. As before, these are more conspicuous in monochromatic than in white light, and the scale being different for different colours, the overlapping of the colours rapidly destroys the clearness of the bands as seen by white light.

17.—Similar Bands of Colour may be observed within the shadow of a narrow object such as a hair, or around the border of the light falling through a small hole on a screen. A very strange effect noticeable in the case of the shadow of a small circular object is that, at determinate distances from the source of light, the centre of the shadow is a bright spot, the colour of which varies as the screen is moved towards or from the obstacle which obstructs the light.

Even more strange is the effect produced when light falls through a small circular aperture. At one particular distance of the aperture from the source of light and the screen, the illumination at the centre of the bright spot is four times as great as if the screen which contains the aperture were altogether removed, and by doubling the size of the aperture, instead of increasing the illumination, we obtain a black spot at the centre of the illuminated space. These effects of interference are due to exactly the same causes as in the case of sound, but the extreme smallness of the wave-length of light, which may be taken to be about 1/50,000th of an inch for light of mean refrangibility, compared with ordinary objects which produce shadows, and with ordinary apertures, render them inconspicuous in general.

18.—The bands of colour obtained in Diffraction Phenomena, when white light is employed, and before the mixing of colours has masked all variation of intensity of light, may be made to afford a spectrum of great purity, and the dark lines and bands of the refraction spectrum are very readily studied in the diffraction spectrum when, by due precautions, it has been made to extend sufficiently in length. The measurements of wave-length are more readily made in the spectrum as produced by this method. For these purposes, the light is generally reflected from a surface on which a series of equidistant parallel lines are ruled very close together. Formerly, 3,000 lines to the inch was con-

sidered sufficient for the purpose, but Prof. Rowland of Baltimore has devised means for ruling gratings which contain nearly 30,000 lines to the inch. Spectra of great purity are thus obtained, and the results are highly satisfactory.

19.—The colours of MOTHER-OF-PEARL and of BARTON'S BUTTONS are due to the fine striation of the surface in either case. Impressions of mother-of-pearl on black sealing wax shew the brilliant tints almost as well as the original surface. Fine powders, such as that of LYCOPODIUM (the spores of *Lycopodium clavatum*), when scattered on glass and viewed by transmitted light, shew well-marked coloured rings, owing to diffraction, and the rings seen round some stars, especially in small telescopes, are due to the same cause. It is estimated that it would be impossible to conceive of any microscope which would render visible objects less than 1/120,000th of an inch in diameter, owing to the inevitable diffraction effects connected with viewing them.

20.—**Colours of Thick and Thin Plates.**—If the front surface of a mirror be covered with a finely divided substance, such as is obtained by brushing it with diluted milk, the light which is scattered at the first surface, interfering with that which has undergone regular refraction into and out of the glass and reflection at the back of it, produces a very beautiful system of coloured bands surrounding the image of the source of light. If the mirror be concave, the source of light being at its centre, the rings appear to have a very remarkable fixity of position, independent of the position of the observer.

21.—When a lens of small curvature is pressed against a plane piece of glass, and viewed by transmitted or reflected light, there is seen a system of brightly coloured rings surrounding the point of contact. These are known as NEWTON'S RINGS. They are produced by the interference of the light which emerges after reflection, within the space between the lens and plate, with that which is directly transmitted, or is reflected, at the first surface of this space respectively in the two cases. The transmitted system has a bright centre, the reflected system a dark centre.

In the arrangement of lens and plate, the variations of thickness of the interposed layer of air follows a known law, and hence the wave-length of light of different colours may be calculated

from the size of the rings of those colours. It is necessary to add a retardation of half a wave-length at each reflection taking place in glass at a surface separating glass and air, an addition which is in perfect accordance with what would be anticipated by theory, and is, in fact, necessary for the continuity of the motion. But for this the centre of the reflected system would be bright, not, as is the case in fact, dark. The above conclusion as to the position of a given colour in the series is modified by this fact.

The iridescent colours given by a drop of oil or turpentine on the surface of water, by the thin scales of the wings of some insects, by thin films of mica and other readily laminated bodies, and by soap-bubbles, are all due to the same cause. Two streams of light, which in their passage to and from the thin film have traversed paths of slightly different lengths, are brought to the same point. At one place they strengthen each other; at a neighbouring place the displacements due to them are opposed, and they extinguish each other. For one thickness of the film the difference of path may be an exact multiple of half a wave-length for a particular colour, which will therefore be wanting at that place, and the film will in consequence appear coloured. For different thicknesses the colours will be different.

22.—Though the sensation of light is not produced by radiations whose wave-lengths are greater than that of red light or less than that of violet, the nature of such radiation is not different from that of the intermediate wave-lengths. Beyond the extreme red end of the spectrum we find radiation which possesses the power to heat bodies exposed to its influence, and in this part, as well as in the visible part of the spectrum, there are evidences of lines of absorption in the sun's radiation.

Beyond the violet end of the spectrum also, there are radiations possessed of very strong actinic power, and capable of being rendered obvious by their action on sensitive photographic plates. Probably one reason why photographs of celestial objects sometimes shew details not visible to the eye is that they are due to radiations of shorter wave-length than the extreme visible part of the spectrum.

23.—**Fluorescence.**—Celestial photographs reveal faint stars owing to a different reason. The effect of a light sensation on

the eye endures for no more than 1/7th of a second. If an object be so faint that the light which it transmits to the eye in this brief period is not capable of exciting the optic nerve, nothing is seen, but the photographic plate may be exposed continuously for many hours, and so, by the continued action of a feeble excitant, effects may be produced which become visible. Besides affecting sensitive plates, these ultra-violet rays possess the power of causing certain changes in a large class of bodies known as FLUORESCENT bodies. These bodies possess the strange characteristic of absorbing radiations of short wave-length, and, by so doing, being excited so as to emit radiations of wave-lengths sufficiently long to affect the eye. Such substances are Sulphate of Quinine, Aesculin, Petroleum Oil, Eosin, etc.

A somewhat similar phenomenon is manifested by the sulphides of Barium, Calcium, and Strontium, and some other bodies, which, when exposed to light for some time, are afterwards able to emit light which can be seen in a dark room. The phenomenon is known as PHOSPHORESCENCE, and has a practical application in the manufacture of luminous paints.

24.—Besides actual changes of colour such as these, there is an apparent change produced by the motion of the source of light in the line of sight. The cause and the extent of the change are determinable by exactly the same principles as in the analogous case of the change of pitch of sound emitted by a moving body. The phenomenon enables us to extend our knowledge of the motions of the stars, and to measure their motion towards or from the solar system with great accuracy. By this means, too, the violent eruptions connected with the formation of solar spots are rendered capable of measurement, and certain double stars which are too distant to be separated by the telescope are known to be double, from the fact that the spectroscope proves their light to emanate from two bodies moving with different velocities.

25.—Though not directly connected with the subjects of this article, the above phenomenon, and a further application of the spectroscope to the study of solar physics are too important to leave unmentioned. The sun was observed in 1842, when totally eclipsed, to be possessed of appendages which created much surprise, and a good deal of debate as to their nature and origin.

Red flames were seen on the border of the eclipsed sun, some of which changed their form, while others remained apparently stationary. The study of these forms progressed but slowly, owing to the rarity of the opportunity afforded by a total solar eclipse.

In 1868, however, it was found possible to observe them in full daylight, owing to the fact that their light does not give a continuous spectrum, but only a few bright lines. These lines are not weakened by great dispersion, while the bright background of sunlight can be rendered more and more faint by employing larger and larger dispersive powers, and by the use of a suitable absorbing medium. If, now, instead of allowing the light to pass through a slit, the margin of the Sun's disc is viewed directly through the spectroscope, the bright lines produced by the slit will be replaced by a succession of images of these jets of flame. By this means the PROMINENCES are now the subject of continuous study. They consist very largely of hydrogen, and some of them extend to 100,000 miles from the sun's surface, being, on occasion, shot forth with velocities reaching to 100 miles per second, or even beyond.

26.—**The General Structure of the Eye** is, briefly, as follows :

The eyeball is approximately spherical, fitting into a bony socket, in which it is free to turn in all directions with but little friction. It has a tough covering called the SCLEROTIC MEMBRANE, mostly white and opaque, but in front it is transparent, forming the CORNEA. This part is slightly more protuberant than the rest of the eyeball. The body of the eye is divided into two parts, the anterior of which is filled with the so-called AQUEOUS HUMOUR, the posterior with the VITREOUS HUMOUR. These are separated by the CRYSTALLINE LENS. The incident light is partially stopped by an opaque screen, the IRIS, in the centre of which is the PUPIL, which is circular in man, though of different forms in some other animals. This part of the eye serves simply to bring the light from external objects to a focus on the retina. At the back of the eye, within the sclerotic membrane, is another coating called the CHOROID, and between it and the vitreous humour is the RETINA. Over the retina spreads a fine network of nerve fibres, uniting in the OPTIC NERVE, which runs into the brain.

This layer of nerve fibres is followed by several other layers,

containing granules, and finally we find the BACILLARY LAYER, which consists of a set of elongated bodies, arranged radially, and closely set together. These are of two kinds, known as RODS and CONES. It is believed that the distance between two neighbouring rods or cones determines the smallest angle between two bodies which are just seen as two. The perception of light is due in some way to the presence of the bacillary layer, for it is tolerably certain that the nerve fibres overspreading the retina are incapable of being directly excited by light vibrations. The general surface of the outer ends of the rods and cones of this layer is in contact with a layer of cells containing a black pigment, which is supposed to serve the purpose of absorbing stray rays of light.

CALIFORNIAN TRAP-DOOR SPIDER.—At a meeting of the Academy of Natural Sciences of Philadelphia, held June 23rd, 1896, the Rev. H. C. Cooke reported a series of observations on the Californian Trap-door Spider, *Ctenizа Californica*, made by Dr. Davidson, who had been able to determine the time required for the construction of the burrow in confinement, and other matters connected with the life-history of the animal. It had taken ten hours to construct the nest with the hinged door, another spider having made a hole large enough to conceal itself in two hours. The method of digging was the same, in the main, as that described by the speaker for the tarantula. The young, when they emerge, at once build their own miniature nests, which are renewed every spring, until they reach the full size. Based on his study of a Lycosid, the speaker had predicted that the enemy of the Trap-door Spider would be found to be a diurnal wasp. Dr. Davidson has established the fact that such is the case, and that the attacking species is *Parapomphilio planatus*, Fox.—*Science.*

A Rapid Method of Preparing Permanent Sections for Microscopical Diagnosis.*

By Dr. Ludwig Pick.

THE technique used in our laboratory for the microscopical diagnosis of curetted or excised material allows the preparation of sections cut, hardened, stained, and preserved within ten to fifteen minutes—often, even, in less time. The rapidity of the method offers, among other advantages, the possibility of deciding important questions bearing on the pathology of the case during the anæsthesia, or even after the operation has begun, as we have often successfully proved.

We employ the Jung-Heidelberg Hobel (carpenter's plane), ether spray freezing microtome, and, in fact, regard it as an integral part of the method. It yields, with ease and rapidity, a large number of fine, thin, and complete sections with very little waste of ether.

The curetted or excised material is freed from blood and coagula by dipping in water and then brought directly on to the freezing plate of the microtome and frozen. In order that the freezing should be rapid and not too severe, it is important that the mass be laid flat, and not be thicker than 2 or 3 mm. The breadth is immaterial up to 1 cm. square, or even greater. The ice-block so obtained in a few seconds must be merely firm, not stone hard; the knife must cut through lightly and without grating. Particles from curettage may be laid on the plate, a half-dozen or more at once, and sections obtained from all at the same time.

The sections as they are cut are wiped from the knife-blade by the finger-tip, floated into a 4 per cent. aqueous formalin solution, and left there four minutes to harden and fix the cell plasma and intercellular substance. The use of the finger instead of a brush is to allow the warmth of the former to thaw the section before it reaches the solution, avoiding in this way the formation of air-bubbles in the tissue, which are often very annoying. As the formalin hardens at once, the disadvantages so often urged against the freezing method—that is, fragility, loss of epithelial elements,

*From the *British Medical Journal*, Jan. 16th, 1897.

and, above all, the poor staining quality of the sections—are done away with.

From the formalin solution the section is carried directly into a 4 per cent. alum-carmine solution, and left three to five minutes, staining a deep red (4 g. carmine boiled three-quarters of an hour in 100 g. 5 per cent. aqueous alum solution, cooled, filtered). For transporting the sections from one liquid to another up to absolute alcohol, a glass rod is used, about which the section is rolled, obtaining a flat and even specimen much more quickly and conveniently than with a spatula.

The formalin section hardening and immediate carmine staining are emphasised as being the essential points of the method, distinguishing it from others more or less similar.*

The section taken from the carmine solution is rinsed in pure water to remove the superfluous stain, using the glass rod as before, and then dehydrated by bringing it for fifteen seconds each into 80 per cent. alcohol and absolute alcohol. Finally, it is placed in xylol carbol to clarify, and mounted and conserved in Canada balsam. The unused sections and uncut material may be preserved indefinitely in 80 per cent. alcohol, and subsequently stained or embedded by any method, exactly as with primary alcohol hardening.

With us the questions most frequently to be decided by microscopical diagnosis are:—Malignancy or benignancy of tumours, ulcers, etc. These are answered as efficiently and positively by preparations obtained by this rapid method as could possibly be obtained in any other way. Every one using the method will be convinced of the exactness and distinctness with which the preparations show the proliferation and change of form of epithelium, abnormalities in number and development of glands, typical and atypical gland forms, decidual cells, placental residua, etc. Naturally, this procedure, which has been tested by us only in gynæcological practice, would seem equally suitable for use in other fields where a quick anatomico-pathological diagnosis is required, and we hope that its wider use will confirm this view.

* T. D. Calluis, *Centralb. f. allgem. path. u. Path. Anat.*, 1895.

The Planet Mars: Is it Inhabited?

By W. D. Barbour,

Of the Leeds Astronomical Society.

AMONGST the myriads of Suns and Planets which throng the vast abysses of celestial space on every side, is it possible to conceive that this little Earth of ours, in proportion like a grain of sand or a floating sunbeam mote, is the only spot upon which life has evolved and human-like intelligence dwells? So extravagant a supposition is not only incongruous to reason and opposed to analogy and continuity, but is also inconsistent with our conceptions of an all-wise, omnipotent Creator. Thus encouraged by many sanctions, the astronomer could scarcely aspire to a nobler discovery than demonstration, by objective proof, of the existence in yonder skies of intelligent life constituted mentally, if not physically, like ourselves.

Hitherto, it has been supposed that the main essentials to discovery lay in the size and excellence of the investigating telescope. Experience has now shown that, all-important as quality of telescope may be, the condition of the atmosphere through which the light from the planet or star reaches the eye of the observer, is the main factor which determines success. In harmony with this fact, the careful scrutiny to which Mars has been subjected in recent years, has yielded the best results, not to the largest telescopes, but to those of less aperture when erected in lofty positions away from large populations and atmospheric impurities. But even here, another difficulty confronts the observer which he cannot control. The diverse temperatures and cross currents of the different air strata, extending to many miles above our heads, interfere more or less with direct passage of the light-rays downwards to the telescope. Thus, instead of clearly defined surfaces of planets and round discs of stars, we have blurring in the first instance and distortion in the second. These difficulties the astronomer meets with endless patience and watchfulness, waiting for those brief intervals, often one to three seconds only, when the overhead atmosphere is steady and without cross-currents.

These precious moments are the astronomer's opportunity and reward. The finer details of the planetary surfaces come out with startling distinctness, and he sees in a moment that which hours of the intensest gazing had failed to reveal. Thus, it came to pass that Schiaparelli's "Canals in Mars," partially discovered nineteen years ago, were largely treated, even by astronomers, as myths of the imagination. But just as truth can always afford to wait, so vindication came at last from the pellucid air of Arizona, where three astronomers at the Observatory at Flagstaff, East of California, watched the planet Mars from May 24th, 1894, to April 3rd, 1895. During that time, to mention nothing else, nine hundred and seventeen drawings and sketches were made. And since the date named, it may be added, confirmation and new discovery have served but to endorse the general accuracy of the observations of the astronomers referred to.

As a rough approximation to the visibility of Mars, when telescopically examined, we may here say that an opera-glass, magnifying three or three and a half times, shows our Moon about as plainly, and with detail similarly pronounced, as a colossal telescope, eighteen or twenty inches aperture, under the highest favourable conditions and in exceptional moments, would, with a power of say four hundred, reveal to us the markings on the planet Mars. Young amateur telescopists may be interested in knowing that the writer, with his four-inch aperture, achromatic, in Leeds outskirts, while observing Mars in December, 1896, between one and two a.m., during one of those brief precious intervals of atmospheric steadiness, saw distinctly (using diagonal, Mars being in Taurus, and near zenith) what he recognised as Syrtis Major skirting the Eastern limb, also shimmering darkish bars upwards to the right which he identified as Oceanus, Mare Icarium, and long arm of Margaritifer Sinus, the whole covering an equatorial width of three or four thousand miles. Mars at this observation was more than fifty-three millions of miles away, a distance which an express train, travelling fifty miles per hour continuously, would require more than a hundred years to traverse. One of our Members (Mr. Townshend), with his nine and a half inch reflector, it need scarcely be added, has seen much more on the planet than what is described above The polar snows, when

of considerable size, are easily visible in a good telescope, five or six feet in length.

The first recorded drawing of Mars is one by Huyghens, November 28th, 1659, and is faithful enough to be now recognised as the Syrtis Major. In recent years, many drawings of the planet have been made (some of which appeared in the Transactions of the Leeds Astronomical Society for 1894, one showing the dark line bordering the snow-cap, which Mr. Lowell comments upon at length, named the "South Polar Sea"), but not until the astronomers named, with whom we must associate the Italian, Secchi, concentrated their unwearied energies upon the question, Did Mars divulge, what appears to many, the life secret of its end and destiny?

The three principal features upon Mars, its snowy caps and light and dark areas, had long been observed, studied, and commented upon. Many strange discrepancies, however, were noted. Light and dark areas were seen at one time, and not at another. The colours assigned to them also varied. To Humboldt they were a puzzle; Secchi says, "bluish, owing to absorption; and orange, sometimes dotted with red, brown, and greenish points"; Beer and Madler, "dull grey green"; Proctor and Parkes, "ruddy and greenish"; Lockyer, "reddish and greenish"; Guillemin, "reddish and dark bluish." These observations we now know to have been just and accurate; but the cause of these differences, partly one of personal equation, has now, as will appear hereafter, received an explanation which harmonises well with other recorded facts and theories.

To the three prominent features above named, the Italian and American astronomers, undoubtedly favoured by the purity and transparency of their local atmospheres, have added two more of absorbing interest. Scores of fine delicate lines have been seen and located. Out of one hundred and eighty three so-called "canals," nine have been seen once, seventy-nine two to nine times each, and ninety-four from ten to one hundred and twenty-seven times each. Sixty-four spots, some circular and some oval, have also been located. Very significantly, the lines seem, with scarcely an exception, to be prolonged from spot to spot, each spot being the junction or centre whence radiate from two to nine of the "canals."

Mr. Lowell draws attention to three remarkable characteristics of these lines: 1.—Their unnatural straightness, so different from anything of the kind observable upon Earth. Almost invariably they are arcs of great circles. 2.—Each line appears the same uniform width throughout. 3.—No line is absolutely isolated, which means that, starting from any point on any line, the whole network of lines might be successively traversed. In regard to these characteristics, it may be observed that angularity or deviations from straightness, also intervals or interruptions in the canal system, even to the extent of fifteen miles or more in each case, would not be perceptible from Earth in the best of telescopes. Such deviations, rendered necessary to round hills here and there, are indeed to be expected; but nothing conceivable in the canal system would necessitate absolute discontinuations. Stretches of sandy desert might indeed occur here and there, useless for irrigation purposes, but through which the water could easily be conducted without loss.

Perhaps the most inexplicable phenomenon upon Mars is the gradual widening, then doubling, or splitting in two, of what at first appeared as a single ordinary canal. Mr. Lowell's map shows seven of these double canals, the distance between the lines in each case measuring from one hundred and twenty to one hundred and seventy-five miles, the intermediate country being of an orange-ochre tint. From the fact that other lines appeared on the point of doubling, and others, again, very broad, it may turn out that doubling is rather the rule than the exception. Mr. Lowell believed the doubling (one or two cases of tripling have been recorded) to be seasonal and vegetal. The theory is plausible, though unsatisfactory, he thinks, which sees in the slow divergence of the lines a progressive growth and decay, as the lines of vegetation recede from each other. In every case, he says, the lines appear straight and exactly parallel; and the better they are seen the straighter they appear. The solution of this strange doubling cannot fail to be significant and intensely interesting when it comes.

One of the most telling points in Mr. Lowell's contention that the dark areas are not water, is the discovery that dark lines and dark spots are not confined to the light reddish or sandy-coloured regions, but prevail also in the dark regions; in fact, the

lines in the light regions converge to a remarkable extent to the obtruding peninsular points in the dark regions, from whence, after repeated crossings, they are continued in new dark lines, each measuring from about one thousand to two thousand two hundred miles, up towards the South Pole. Owing to the bending of the South Pole towards our Earth at the last opposition (October, 1894, a position which will not again occur for fifteen years), and the consequent bending away of the North Pole, it could not be ascertained whether similar lines converged towards the latter. The width of the lines Mr. Lowell estimates at fifteen miles for the finest, up to forty-five or more for the broadest. In length they vary from two hundred and fifty miles to one thousand five hundred miles; and in one instance, involving ten oases in a straight line, to three thousand five hundred and forty miles; that is, longer by one thousand miles than a straight line from Leeds to our North Pole. The spots, or oases, in the deserts of Mars vary in diameter from seventy to one hundred and fifty miles, the larger forming the majority. The largest of all, Solis Lacus (Lake of the Sun), is five hundred and forty miles long and three hundred broad. Remembering the width of these lines (fifteen to forty-five miles), it is obvious that a city like London, say fifteen miles in diameter, upon Mars, would be quite invisible to us in our largest telescopes. Why these marvellous spots and intricate lines should have remained undiscovered from Herschel's forty feet Reflector in 1789, and Rosse's gigantic fifty-four feet in 1845, till Schiaparelli, in the Italian sky, with an eight and a half inch aperture, detected them in 1877, we have already explained. That they may have been seen, and yet not recorded, is of course possible, remembering their seasonal character and fitful appearances, and to that extent their difficult identification.

To a correct understanding of the enormous areas covered by the supposed deserts, ancient sea-bottoms, spots, and lines visible on Mars, let us make a comparison. Our Earth is seven thousand nine hundred and eighteen miles in diameter, twenty-four thousand eight hundred and seventy-five miles in circumference, and in superficial area one hundred and ninety-seven millions of square miles, of which one hundred and forty-six millions are water, leaving fifty-one millions land, including North and South Polar

regions. Mars, a much smaller planet, is four thousand two hundred and fifteen miles in diameter, which, multiplied by its circumference, thirteen thousand two hundred and forty-one miles, shows its area to be nearly fifty-six millions of square miles, from which, deducting an average of six and a half millions for North and South snow-caps, we have forty-nine and a quarter millions of land only, which is more than the entire land area of Europe, Asia, Africa, and America combined. It will surprise many to know that out of the entire land area of our Earth, viz., fifty-one millions of square miles, about twenty millions have not been explored at all, estimated thus:—Africa, six and a half millions; Arctic and Antarctic regions, nine millions; other parts, four and a half millions. As would appear from the extent of country covered by lines, our Martian cousins may be far ahead of us in the work of exploration.

An important correction to our former beliefs lies in the discovery that the large dark areas on Mars are not seas, but in all probability the bottoms of ancient seas, which are flushed at certain seasons by extensive freshets from the melting snows at the North and South Poles. These waters, never apparently very deep, disappear during summer and autumn, being either absorbed by vegetation and the subsoil, or vapourised into the atmosphere. We thus arrive at the pregnant inference, if Mr. Lowell's observations be confirmed, that a great scarcity of water exists upon Mars, at least upon the surface, and as scarce there as it is plentiful with us. Referring again to the strange periodical disappearance of the dark areas, also the various changes in colour, recent observations not only confirm these variations, but add similar changes in colour and visibility of the spots. Some hidden unknown cause was here at work. That large markings should come and go in this way, showed changes to exist on a scale involving a large portion of the planetary surface. In a correct interpretation of these changes evidently lay the key to the unlocking of the mystery of Mars. The exhaustive scrutiny of astronomers during the past forty years, culminating in those of Schiaparelli and the Arizona observers, may turn out to have brought us within measurable distance of the true solution.

Geology tells us that our oceans are gradually filling up with

the soil and detritus ever being carried down from mountains and lowlands by means of streams and rivers. The same story of denudation and wearing down, we now have reason to believe, was long ago enacted upon Mars, with the ultimate result, as seemingly proved by Mr. Lowell (discussed and allowed, also, from a geological point of view, by Mr. P. F. Kendal, F.G.S., in an illustrated lecture before the members of the Leeds Astronomical Society last year), that the surface of Mars is now nearly level, its oceans having retired into the interior; and yet not altogether so, for the saturated, though now extremely attenuated, atmosphere of the planet still continues its circuit, depositing its watery treasure in the form of snow or hoar frost, during the long polar nights. With returning spring, these snows are observed to melt; and the water, which appears in the telescope of a deep blue colour, to collect as a ringed sea, three hundred and fifty miles wide, surrounding each pole.

That Mars is not exactly level, however, but has hills, at any rate, near the South Pole, more or less perpendicular, is shown by Mr. Lowell's observation on June 7th, 1894, about one hundred and thirty-five days before opposition. Suddenly, two points like stars flashed out in the midst of the polar cap. Dazzlingly white on the snowy background, they shone for a few moments and then slowly disappeared. These afterwards proved to be gleams of Sunlight, reflected from steep ice slopes, flashed earthward, just as in a railway train we sometimes see the light of the Sun reflected towards us for some moments from a distant glass conservatory. As this ice slope was near the pole, answering to Victoria Land near our South Pole, the Sun must have appeared near the horizon, from those shining points on Mars. The same eminences were afterwards observed as ice or snow patches amid dark surroundings, suggesting a colder elevation, like the snow on our hills, which remains days, sometimes weeks, after the snow in the surrounding valleys has melted. It turned out that these ice flashlights had been seen in 1846 and 1877; also two others in addition. In connection with these, many will recall the supposed light-signals from Mars, which gave rise to so much speculation at the time. Martian astronomers may possibly be familiar with similar Sunlight reflections from our lofty regions of eternal snow and ice.

Three great dark rifts were also seen during the last opposition of Mars, one increasing in nine days from one hundred miles to three hundred and fifty miles. This again points to the existence of hilly portions near the South Pole, the dark rifts doubtless showing where the ground was low, and from which consequently the snow had disappeared most quickly.

During the opposition named, 1894–5, it was remarked that the South Polar Cap did not extend symmetrically round the pole. In long. 206, the snow extended only to lat. 71, or 19 degrees (six hundred and ninety-eight miles) from the Pole, answering to our North Cape; whereas in longitude 26 it extended to $54\frac{1}{2}$, or $35\frac{1}{2}$ degrees (one thousand three hundred and four miles) from the Pole, answering to our British Columbia. Comparing these with our terrestrial snows, we note that here in Yorkshire, 36 degrees (two thousand five hundred miles) from North Pole, we have frequently rigorous winters of snow and ice; and even in New York, 50 degrees (three thousand four hundred and seventy-five miles) from the Pole, the snowstorms are now and then appalling in their severity. It should be remembered that a degree on Mars measures thirty-six and three-quarter miles, against sixty-nine and a-half miles upon Earth. Why the Martian snow-caps should thus extensively diminish in area during summer (actually disappearing in 1894, for the first time known to astronomers), as proportionately contrasted with the perennial ice-caps of Earth, has not yet been satisfactorily explained. According to accepted theory, the cold at the Martian poles, owing to much greater distance from the Sun than Earth, also to the thinness of its atmosphere, should be continuously much more severe—that is, far below freezing point. A partial explanation has been found in the thinness of the ice-coating, due to the limited quantity of water-vapour which its atmosphere can carry and deposit as snow; also, in the absence of a deep Arctic ocean, in which more ice would, almost certainly, be formed in winter than could be melted during each succeeding summer.

Some years ago, as many of our readers will remember, there was much talk amongst a section of the public about signalling to Mars, by arranging upon some vast plain certain geometrical figures, which, when seen by Martians, would testify to the exist-

ence upon Earth of an intelligent and cultivated people, and should amount to a preliminary invitation to further correspondence. Such people were unaware that, even if the idea were good and promising, such lines would require to be four hundred or five hundred miles long and some fifty miles broad. But oh, the irony of the matter! Here, Terrestrials, in their simplicity, have been discussing how to open communication with Mars, and all the while, these supposed cousins of ours, in their intricate and scientifically arranged network of vast engineering schemes, extending over thirteen thousand two hundred miles by at least three thousand six hundred and seventy-five miles, thus setting absolutely at naught our most gigantic achievements, have been practically signalling to us for, not only hundreds, but quite possibly thousands of years; and if their astronomical at all equal their mechanical and engineering skill, they have doubtless been watching and waiting for some responsive sign that beings, of intellectual calibre equal to themselves, existed upon Earth.

We gather from Mr. Lowell's observations that this polar sea water not only flows out on all sides towards the Equator, thus irrigating the large dark areas, but by means of gigantic canals is tapped, conveyed, and distributed to the numerous oases or junctions in the reddish ochre desert regions, which seem to serve as centres for the further distribution of the precious liquid. At the 1894 observation, these canals were first observed on May 31st (after Mars' Vernal Equinox on April 7th, 1894), in the dark areas about the Syrtis Major; and soon after this, in June, there appeared, as the result of the snow melting, "one continuous belt of blue-green, obliterating the whole intermediate reddish-ochre regions, and stretching from the Syrtis Major to the Columns of Hercules." After this, their history was one long fading out, from various shades of colour, interspersed with glints of orange-yellow, until finally, with some intermittent changes, the spring and summer verdure had changed to an orange-ochre. The long dark lines which in June had joined the Polar Sea to Syrtis Major, had also by October nearly disappeared, and a month after this what remained of the more Southern dark areas had faded, so as to be scarcely perceptible. To the question, What causes these vast and wholesale changes from blue-green to orange-ochre? Mr. Lowell

replies that no theory about water and its reflection of light can explain them. Professor Pickering's polarising experiments on the light from these blue-green areas, made some years ago, and repeated along with Mr. Lowell, also ended in the same verdict. The only thinkable alternative, therefore, is that the colour-changes are caused by the seasonal development of vegetation from green through bloom to the "sere and yellow leaf" of decay. It need scarcely be added that the lines which the telescopist sees, are not the "canals" or water-courses, but the fringes of vegetation bordering the "canal," and extending for some eight to twenty-five miles on each side. As regards the general order in degree of visibility, it is noticed that the first areas, lines, and oases to become deeper in tint, are those nearest the polar snows; those near to the Equator being the last (except those running east and west) to receive the benefit from the Martian annual freshet.

The question will occur here to many minds:—Like as Earth contains, in addition to springs, reservoirs of fresh water everywhere near to its surface, and which are available for human consumption, may we not suppose that on Mars, a planet so analogous in many respects to Earth, a similar provision may exist for the necessities of its supposed inhabitants? From the fact that Mars is a much smaller planet (in volume 15, in mass 11, in density 72, in diameter 53, and in surface 28, each against Earth's 100), and therefore having cooled much more rapidly than Earth, we may reasonably conjecture that near its surface it is more extensively honeycombed; and therefore that its reservoirs of rain-water are proportionately more numerous. Against this theory we have the fact that Mars, as an inhabitable planet, must be enormously older than Earth, and therefore that its initial stores of water may have drained too deeply inwards to be accessible. In the supposition, also, of an ever-increasing drought during thousands of years in the past, it is open to us to conceive that the inhabitants may have been drawing, largely and continuously, upon these internal stores of the precious fluid.

The entire evidence, including that from analogy and continuity, thus goes to show that we are here dealing with a world substantially like our own in origin, history, elementary composition, and structure, but much older than Earth, and therefore

differing in detail, such as density of atmosphere, quantity of water, cloud formations, and contour of surface. But on the face of the planet we see something startlingly unlike anything upon Earth, and having no resemblance to geological or glacial cracks, volcanic rents, river ways, or the coursing impact of tiny planetoids. A strange gigantic network of lines encompasses the entire globe. Apart from artificiality, they stand utterly opposed to reason and explanation. They are matched only by the fabulous deeds of the mythical gods of old.

Thus seemingly compelled to accept the evidence for these superhuman-like structures, it by no means follows that our Martian neighbours are necessarily prodigies of mind and body as compared with ourselves, or rather, with what we might attain to by lives of righteousness and culture. Rather the contrary, indeed, if size of habitat and similarity to our own environment are to count. And another objection must be reckoned with. The Martian atmosphere is excessively tenuous, much thinner even than that on our Himalaya Mountain tops. No clouds of consequence ever veil its surface. If, therefore, mental and physical labour are to be construed in terms of consumption of carbon and of other chemical elements, as in our own case, we must conclude that the Martian lung capacity is either much larger or more active than with us, to produce a like equivalent of work. How then, with these drawbacks, are we to account for the Martian ability to execute such colossal designs? To this we reply: 1.—That the feebler gravitation on the Planetary surface (38 against Earth's 100), necessarily increasing the ease of muscular exertion, may largely compensate for atmospheric deficiency in oxygen, the inbreathing of this element in sufficient quantity conditioning the amount of animal life and activity. 2.—Given the gradually increasing necessity for such works, during, say, tens of thousands of years, "time being thus on their side," the superhuman element to account for them becomes superfluous. "Strength for their day" would be the lot of each generation. What is suggested in these stupendous evidences of a civilisation possibly exceeding our own, is the existence of some constitutional peculiarity in the planet or its inhabitants, or, on the other hand, some relentless antagonism in the forces of nature,

which are now being successfully combated by the united energies of an entire world.

And now, in summing up, as to the meaning of all this. These lines, parallels, and round or oval spots (which exuberant fancy might easily endow with a martial meaning), cannot mean the unconscious working out of nature's laws, such as we see on the rugged surface of our Moon, or in the lonely uninhabited regions of Earth, for in Mars we see order, not disorder; method, not chance; arrangement, not confusion. What impressed Mr. Lowell, as he sketched by the side of his telescope, during the still hours of night, was the obvious unity of design and purpose, with the high order of intelligence and skill, which are evident in these enormous works, compared with which our Suez and Manchester Canals are absolutely insignificant. He describes them as "uncanny" in their aspect, such being his impression of their living or life-like origin. Acquiescing then, for the present, in Mr. Lowell's interpretation and verdict, we inquire further—For what purpose all this world-wide expenditure of mental, physical, and mechanical power? Our answer, whatever it is, must involve a necessity equivalent in urgency to a fight with death. And so it is. An ever-threatening famine of water seems the inevitable lot of our Martian cousins. This is their "struggle for life;" world-wide as the air they breathe, involving all classes, peoples, and tongues; and written as with a pen of iron on the face of the planet itself. Like as community of interest tends, where confidence dwells, to harmony and unity in council, so these wonderful structures suggest to us mutual faith and co-operation on a scale of unparallelled grandeur, before which national jealousies must sooner or later sink and disappear. Unification and inter-dependence of the entire canal system become the pledge of universal peace. Thus we see, as of old, "the curse turned into a blessing." Just as a famine of water, made possible at any moment by destruction of the waterways, means death everywhere to vegetation, animal life, and man or his Martian congener; and just as one touch of sympathy, suffering, and self-sacrifice tends to make divided communities, nations, and even distant worlds, "one kith and kin," so we may hope that strife and bloodshed, with selfishness the bane of life and root of

evil, if ever these have cursed the soil of Mars, have ere now passed away; and that "peace and good-will," revealed from above, now reign in that world of life.

British Hydrachnidæ.

By Charles D. Soar. Part VII. Plate VII.

Genus IX., Atax (Fabricius).

1805.—J. C. Fabricius, *Systema antliatorum*, p. 364.

THE chief distinguishing features in the genus *Atax* may be briefly described as follows:—The epimera are arranged in four groups; the eyes widely separated; the legs are furnished with swimming hairs; and it will be noticed that there are claws to all the feet. This hydrachnid is soft-skinned. The anterior pair of legs is fitted with powerful jointed hairs, the jointed base of each hair being let into a prominent and specially projecting socket.

A great number of so-called species of this genus have been figured and described by various Continental acarologists. Koch figured a great many, but on careful examination the majority of them have been found to be the same species under different names. In 1894 Dr. Piersig made a new genus of certain species which had always been previously regarded as true species of the genus *Atax*, which he named *Cochleophorus*. But this will be referred to later on.

I can find very little information about *Atax* in any English works treating on the subject. Murray, in his *Economic Entomology*, p. 154, has but very few words to say about it. He mentions four species, three of which are very doubtful. In the fourth edition of the *Micrographic Dictionary*, p. 85, will be found a very good description of the genus; it, however, gives but little information about the different species. On Pl. VI., Fig. 14, it also gives a figure of a *Limnesia* under the name of *Atax histrionicus*. This is an error that Murray also falls into, but which is not at all to be wondered at when we consider the scanty information available at the time those notes were written. The *Journal of*

the Royal Microscopical Society, 1871, p. 184, and *The Annals of Natural History*, Jan., 1871, p. 55, have a few observations on a species of *Atax* parasitic upon fresh-water mussels by Emil Bessels which are worth reading, and are very interesting. *Science Gossip*, 1883, p. 180, has a short article on *Atax* by Dr. George, in which he figures and describes the swimming hairs so peculiar to this genus. This completes the list of English papers so far as my own knowledge goes, but on the Continent *Atax* has received some considerable amount of notice. Van Beneden, in 1848, published a paper on the "Development of *Atax ypsilophora*," which has received a great deal of attention, and justly so, for it is well written and well illustrated, and was the result of several years' devotion to the study of these interesting creatures. Koenike also has a paper on *Atax* in *Abhandl. d. naturwiss. Verein zu Bremen*, 1882, without figures. Besides the above, the species we are about to consider has received a great many notices, and has been recorded a great number of times, as will be seen by the following list; but regardless of the frequency with which it has been recorded, we must add one more paper to the list :—

ATAX CRASSIPES (Müll.). Bibliography and synonyms :

1776.—*Hydrachna crassipes*, Müller, *Zool. Dan. Prodr.*, p. 189, No. 2254.

1781.—*Hydrachna crassipes*, Müller, *Hydrachnæ*, p. 41, Pl. IV., Figs. 1—2.

1793.—*Trombidium crassipes*, J. C. Fabricius, *Ent. Syst.*, II., p. 400.

1805.—*Atax crassipes*, J. C. Fabricius, *Systema Antliatorum*, p. 366.

1835-41.—*Atax crassipes*, C. L. Koch, *Deutschlands Crust.*, etc., p. 7, Fig. 21.
Atax truncatus, as above, p. 7, Fig. 22.
Atax abbidus, as above, p. 7, Fig. 23.
Atax truncatellus, as above, p. 37, Fig. 17.

1842.—*Atax crassipes*, C. L Koch, *Uebersicht des Arachniden-systems*, S. 7, Tab. 1, Fig. 1.

1854.—*Atax crassipes*, Bruzelius, *Beskr. ö. Hydrachn. som. Farek.*, p. 8, Figs. 1—4.

1868.—*Atax crassipes*, Claparède, *Zeitschr. f. Wissenschaftl. Zool.* Bd. XVII., p. 471.

1875.—*Atax crassipes*, Kramer, *Beitr. zur Naturgesch. des Hydrachnider*, p. 293, Twf. VIII., Fig. 4.
1879.—*Atax crassipes*, Lebert, *Description D. Hydrachnides du Léman*, p. 45, Pl. XI., Figs. 10—10*a*.
1880.—*Atax crassipes*, C. J. Newman, *Sveriges Hydrachnider*, Pl. XXI., Tab. 1, Fig. 1.
1882.—*Atax crassipes*, G. Haller, *Die Hydrachniden des Schweiz.*, p. 76.
1885.—*Atax crassipes*, Krendowsky, *Hydrachnidæ of Russia*, p. 55.

Average length of body, about 1·20 mm. Average breadth, about 0·92 mm. Average length of legs:—1st pair, 3·70 mm.; 2nd pair, 3·50 mm.; 3rd pair, 2·56 mm.; 4th pair, 3·30 mm. Average length of palpus, 0·84 mm.

Colour.—A pale yellow, with brown markings on the dorsal side, with a yellow T-shaped piece in the centre. The eyes are sometimes dark red and sometimes they are dark brown in colour.

The legs in some cases are quite transparent and colourless; in others they are a deep slate blue. In the autumn of 1896 I took some specimens in Wales, which were very deep in colour. It was, no doubt, this difference in the colour which led Koch to think they must be different species. The form of the upper or dorsal side of body is a long oval, truncated on the posterior margin; at each angle of the truncated margin is a small projection (see Pl. VII., Figs. 1 and 3). The projection on the legs I consider a peculiarity of this mite. The legs are long; the first pair are thick at the first and second joints. These joints, or rather internodes, are fitted with the powerful spines or hairs which we find on no other mites but members of this genus. They are thick near the body, and gradually taper towards the tarsi.

The second pair of legs are the longest, which is a very unusual thing in mites. The second pair measure 0·94 mm. longer than the third pair of legs, and 0·20 mm. longer than the fourth pair. The second, third, and fourth pairs of legs are all slender, and not at all like the first pair, in which the femur and trochanter are so much enlarged. There are two claws to each tarsi (see Fig. 6).

Palpi (Fig. 4) are rather long, the second joint being the thickest. The third is small. The fourth has three pegs—two on

the inner side and one on the outer. The apex of two, if not three, of these pegs is furnished with setæ.

Texture.—The cuticle of the body is soft and easily distorted. The legs, palpi, and epimera are hard and chitinous.

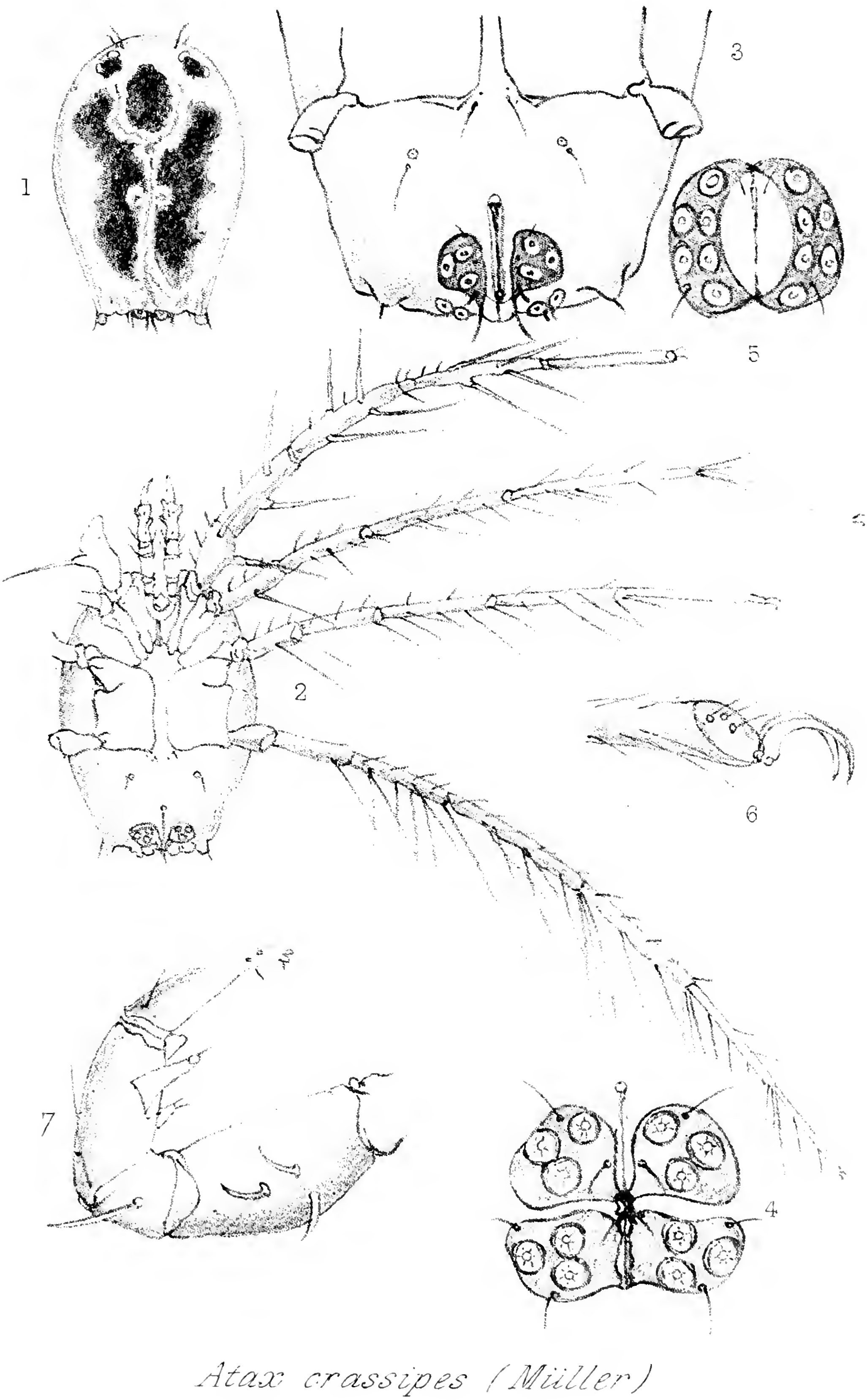
The difference in the male and female is very small. The body of the female is a little more round than that of the male, and the first pair of legs of the female appear somewhat coarser than those of the male; but otherwise the only noticeable difference is in the genital area, Fig. 4 showing the female, and Fig. 5 the male.

Distribution.—This species may be considered as fairly common. I have taken it on several excursions round London, and found it common on the borders of Llyn Padarn, N. Wales. I found it in the rivers in Suffolk, and have had it sent to me from many other places by collectors. The specimens the drawings were made from were taken by me at Snaresbrook on Sept. 19, 1896. They were fine, well grown specimens, but possessed very little colour, the legs and edge of the body being nearly transparent. I have always taken it from clear water in ponds and rivers.

I have kept a quantity of these mites at home alive for some time, but have never yet had any ova deposited in the tubes, so at present the larva is quite unknown to me. In swimming, they swim upwards; they then extend the legs to the fullest and rest, as it were, for a few seconds in the water, as if lifeless, then gradually drop towards the bottom.

EXPLANATION OF PLATE VIII.

Fig. 1.—Dorsal surface of ♀.
,, 2.—Ventral surface of ♀.
,, 3.—Ventral surface of ♂.
,, 4.—Genital area of ♀.
,, 5.—Genital area of ♂.
,, 6.—Claws of first foot.
,, 7.—Palpus of ♀.



Atax crassipes (Müller)

Chas. D. Soar ad nat. del.

F. Phillips Sc.

Leaves from my Note-Book:

Strange Adaptations to the Environment in Water Insects.

BY MRS. ALICE BODINGTON.

I HAVE lately been reading a book* which has much interested me, and which has set me thinking about the strange and wonderful adaptations of some of the tiny creatures inhabiting our streams, ponds, and ditches, to their strange and peculiar environments. Some of the facts in the following paper are gleaned from this book, others from my various readings and personal observation. The illustrations are kindly lent by Messrs. Macmillan and Co.

There is something so extraordinary in the manner in which Water Insects are suited to the life which they have to lead, that one might almost suppose some intelligent power controlled the development of each species without regard to the welfare of any other species; since the adaptation of murderous weapons for seizing and destroying prey are amongst the most salient characteristics of most of these organisms. The film on the surface of water plays an important part in the lives of many water insects. The film, which to our tactile sense is impalpable, is for some creatures a dense medium on which they can execute the maddest gyrations; to others it is a solid crust, *under* which they can run upside down; some insects have organs adapted for piercing this, to them, solid film, so that they can breathe atmospheric air through the hinder part of their bodies, whilst their heads are engaged under water in an active search for prey.

A curious vital process is seen in the manner in which the tracheal tubes of aquatic insects become filled with a *gas*, probably rich in oxygen; an apparatus which, without rise of temperature, or diminution of pressure, will remove dissolved oxygen from water, and store it up in a gaseous form within a closed chamber. Other aquatic animals have a similar faculty; and that this process of obtaining a gaseous mixture is a vital and not a purely

* "THE NATURAL HISTORY OF AQUATIC INSECTS," by Professor L. C. Miall, F.R.S., with illustrations by A. R. Hammond, F.L.S. Cr. 8vo, pp. ix.—395. (London: Macmillan & Co., 1895.) Price 6/-

mechanical one, is shown by the fact that the air-bladder of a fish, when punctured, will refill with a gas containing as much as eighty per cent. of oxygen; but if the branches of the vagus nerve which supply the air-bladder are cut, no more gas is formed. Nor could oxygen be made to diffuse into the air-bladder of a Pike which was filled with atmospheric air and surrounded by pure oxygen, *till the epithelium had been killed by maceration in distilled water.*

The fierce larva of the *Dytiscus* beetle is a kind of sabre-toothed tiger among insects; its sharp curved mandibles are grooved like the poison-fangs of a serpent, and are formed into a tube by the closure of the maxillæ. Whilst the blood of the living prey is being sucked by pharyngeal action through the tube so formed, the maxillæ at the same time act as a mouth-lock. When the *Dytiscus* wishes to swallow a solid morsel, the maxillæ are relaxed and leave the orifice of the mouth open; but the ordinary mode of feeding of this ferocious creature is through its blood-pump. Snails, worms, insects, tadpoles, and fishes, are victims in turn.

The larva of *Hydrophilus piceus*, another water beetle, has an extraordinary provision for keeping itself from undue pressure in its pupa stage, which it passes in damp earth (Fig. 3). On each side of the head (on the forepart of the pro-thorax) it has three strong brown hooks, and two similar hooks are found at the hinder end of the body. These hooks, being solid, could contain no part of the future insect, and the problem was "of what use could these hooks be to a pupa buried in the earth, and left behind when the beetle emerges?" But investigation showed these organs to be essential to the proper development of the insect. The skin of the pupa is very delicate. Buried in damp earth it could hardly escape injury, and the weight pressing on the pupa might distort its frame; but the pupa protects itself from these dangers by assuming an unusual attitude. It extends itself back downwards in a horizontal position, and *supports the weight of its body by the three sets of hooks, as upon a tripod.* In this attitude, though surrounded on all sides by moist earth, it keeps its body from actual contact with any object until it has assumed its final shape. The pupa of *Hydrobius* supports itself upon the floor of

its cell in a similar way, though here the spines cover the whole of the back.

With the exception of the stag beetle, *Hydrophilus* is the largest British beetle; it is not uncommon in stagnant water near London, and in the southern counties. Both in *Dytiscus* and *Hydrophilus* a large part of the surface of the body is adapted to receive and retain a pellicle or flattish bubble of air. Close-set

Fig. 3.—Pupa of *Hydrophilus piceus*, × 2.

hairs are the means employed to prevent the wetting of these particular tracts. [Wrap a strip of velvet round a stick and dip it into water, or sprinkle a few drops of water on a scrap of velvet. You will see with what difficulty the water penetrates the narrow spaces between the threads which form the pile of the velvet. Close, upstanding hairs play the same part in many aquatic insects.] The spiracles open into the spaces which the protecting

hairs keep free from water; these spaces are filled with atmospheric air, which the beetle drinks in energetically, remaining for that purpose at the surface of the water.

The female of *Hydrophilus* constructs a neat cocoon, shaped somewhat like a coracle, containing about a hundred eggs, and to her cocoon she adds a mast, which appears to serve the purpose of steadying the small structure. If the mast be cut off, the cocoon sinks; if it be partially submerged, the cocoon turns bottom upwards. The cocoon is always moored to some floating weed, and the naturalist, Miger, had the good fortune to watch the whole process of the construction of one (Fig. 4). The larva of the small yellow fly, *Dixa*, employs the surface film to buoy up its head and tail; its body being bent into a V, the apex of which

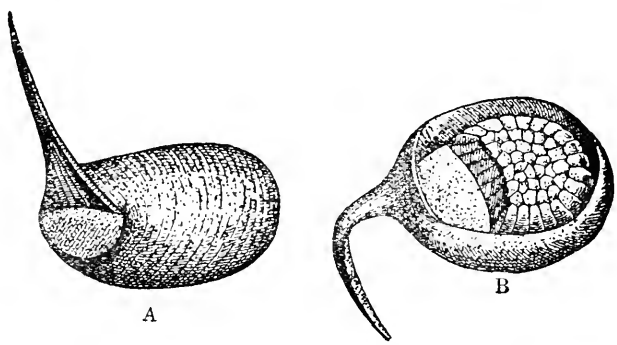


Fig. 4.—Cocoon of *Hydrophilus*.
A shows the mast. *B* is opened to expose the eggs. From Miger.

travels foremost, each half of the V alternately shoving the body forwards. At the tail end is a respiratory cup, furnished with valves, flaps, and outstanding processes, all fringed with long hairs, which serve to exclude the water from a shallow, sunk space, upon which the longitudinal tracheal trunks open. If the larva should slip into deep water, the respiratory cup remains free from water, and buoys up the tail. If the whole body is sunk below the surface, a bubble of air is carried down enclosed in the fringes of the respiratory cup. The larva, when thus submerged, swims energetically, and can readily regain the surface of the water.

The larva of the aquatic fly, *Dicranota*, has elaborate contrivances for hunting its favourite prey, *Tubifex*, a small red worm, to be found at the bottom of muddy pools and slow streams.

Tubifex buries its head in the mud, leaving its tail-end waving to and fro in the water, and draws itself in or out of its burrow by means of four rows of hooks projecting from its body. In order that the *Dicranota* larva may successfully follow the worms into the depths of their burrows, it is necessary that they should be able to travel at tolerable speed through mud and gravel. Five segments near the hinder end of the body are provided with paired feet, each furnished at the top with three circlets of hooks. Almost the whole surface of the body is covered by a dense growth of minute pointed hairs, directed backwards. But the strangest provision of all is that for the safety of the head, which can be completely retracted into the body! The mouth parts of the head bear a pair of mandibles with long curved teeth, and the top of the head is defended with a strong shield. Towards the tail are three pairs of tapering prominences, the hindmost pair being very long and forming the extremity of the body. These appendages are supplied with relatively large air-tubes; moreover, *Dicranota* has also a pair of spiracles, each connected with a large tracheal tube, which runs along the body to the head, giving off many branches to the various organs. The larva seems absolutely indifferent as to whether it breathes atmospheric or dissolved air; but after its tail has been exposed to the air, a bubble can often be seen attached to each spiracle.

The "leaf-eating Beetles" *(Chrysomelidæ)* include a number of species, which pass their early stages upon submerged plants and feed upon the roots. The White Water-lily (*Nymphæa*), *Potamogeton*, the Arrowhead, the Sedges, the Marsh Marigold, the Bulrush, the Horsetail, and other moisture-loving plants, yield shelter to the various species of *Donacia* and its close ally, *Hæmonia*. The female of *D. crassipes* (often found abundantly on *Nymphæa* or *Sparganium*) bites small round or oval holes in the leaves, and through these apparently passes the eggs to the under side, where she arranges them round each hole. The larvæ, when hatched, descend to the bottom, and begin to feed on the roots. They exhibit no obvious adaptation to an aquatic life, no swimming organs, no gills, no peculiar shape, but only the dirty white colour, the small hard head, and the three pairs of pointed legs, found in an ordinary larva which buries itself in earth. Yet

close observation shows a contrivance of an astonishing nature for obtaining air for respiration. Under a magnifying glass, two slender curved spines may be seen projecting from the hinder end of the dorsal surface, and to the bases of these pass the longitudinal air-tubes, which traverse the whole length of the body. At the roots of the spines are a pair of small openings which look like spiracles. Roots of *Nymphæa* examined by Schmidt-Schwedt were observed to exhibit peculiar scars; these were discovered with difficulty, owing to the dark colour and uneven surface of the roots. There was in each case a rough hole, made apparently by the jaws of the larva when feeding, *and at a distance corresponding with the length of the body, a pair of small slits.* These slits were found to penetrate the epidermis of the roots, and to lead to the small irregular air-spaces, which occupy a considerable part of the interior of the roots. Schmidt-Schwedt believes that these slits are made by the spines, and that the air is drawn in by internal channels running along them. Perhaps no contrivance of aquatic insects for procuring air is so remarkable as this tapping of the reservoirs of air of submerged roots.

In the pupal stage a fresh arrangement for respiration has to be made. The pupal cocoon is a close-woven, oval capsule attached to the same roots as those on which the larvæ feed. On the attached side the wall of the cocoon is deficient, and a good-sized hole, previously closed by the root itself, appears when the cocoon is torn away. A number of small holes, penetrating into the substance of the root, appear upon the plant when the cocoon is detached, and it is probably from this source that the pupa derives its supply of air. Wounds in the living tissue are as a rule quickly repaired by a corky growth, but this is not the case with the hole bored by *Donacia* larvæ in the roots of the water-lily. They remain open so long as the cocoon remains attached, and only become closed by cork, when the cocoon is torn open by the emerging beetle, which has remained all the winter in its pupal cocoon.

The surface film plays an important part in the peculiar feeding and breathing arrangements of the larva of the gnat (*Culex*). This larva, when at rest, floats on the surface of the water; but whilst feeding—as it does voraciously—it hangs head downwards,

sweeping minute organisms into its mouth with its vibratile cilia, whilst at the same time it breathes uninterruptedly through the respiratory siphon attached to the eighth segment of its abdomen. If startled, the larva sinks slowly to the bottom by gravity alone, which shows that the body is denser than water. How then is it possible for a larva heavier than water to remain floating at the surface without effort? The possibility of such a thing turns upon the existence of the surface film, formed by the same contractile force which rounds the rain-drop and the air-bubble. The tip of the gnat larva's respiratory siphon is provided with five flaps, which can be opened or closed by attached muscles. When open they form a minute basin, which, though its walls are cleft, does not allow the surface film to enter. At the time when the larva puts itself in position to begin its feeding operations, the pointed tips of the flaps meet the surface film and adhere to it. The attached muscles separate the flaps, and in a moment the basin is expanded and filled with air. The surface film is now pulling at the edges of the basin, and this pull is more than sufficient to counteract the greater density of the body of the larva, which accordingly hangs from the surface without effort. When the larva is alarmed, and wishes to descend, the valves close, their tips are brought to a point, and the resisting pull of the surface film is reduced to an unimportant amount. In its pupal stage the gnat breathes through two respiratory trumpets placed near the head, in such a position that, when the pupa is at rest, the margins of the trumpets come flush with the level of the water. The tail end is now modified as a swimming fan.

The gnat at all stages requires plenty of air, and its egg-raft, containing from two hundred and fifty to three hundred eggs, is as ingeniously contrived for aeration, as are the contrivances at all other stages of the insect's life. If we take two or three of these tiny egg-rafts, and place them in a jug of water, we may pour the water into a basin again and again; the rafts float instantly to the surface, and the moment they come to the top they are seen to be as dry as at first. The fact is that the surface film cannot penetrate the fine spaces between the pointed ends of the eggs. The cavity of the egg-raft is thus over-spread by an air-bubble when accidentally submerged. The eggs are kept from contact with water; the

proper upper surface is so buoyant that the raft has great power of self-righting; while the instant that it comes to the top, the excess of water drains off, leaving the eggs perfectly dry on their upper surface.

The larvæ of the minute gauzy-winged fly, *Simulium*, show a wonderful adaptation to their environment. These tiny worm-like creatures, not more than five-eighths of an inch in length, are perfectly at home in rushing streams and "especially in the rapids above waterfalls." Their food is altogether microscopic; their stomachs are found filled with the flinty valves of Desmids and Diatoms, with here and there bits of a small crustacean. Their mouth parts are provided with fan-like appendages, each

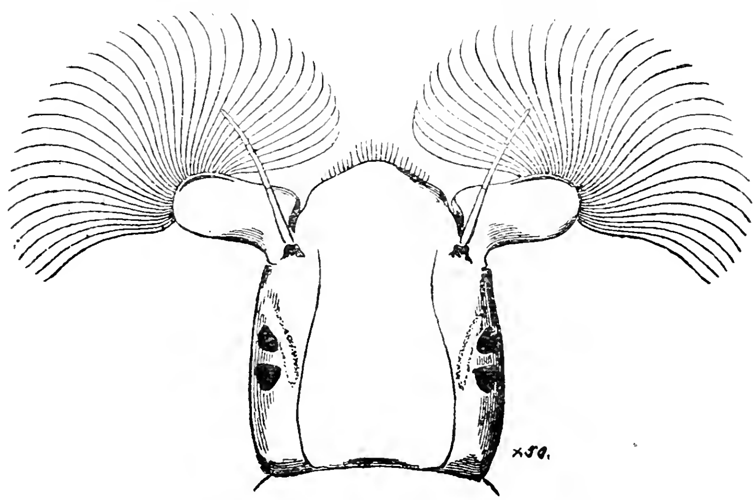


Fig. 5.—Head of larva of *Simulium*, dorsal view, showing eye-spots, antennæ, and fringed appendages.

bearing about fifty long filaments (Fig. 5), which are feathered along one side, and sweep the food into the gullet. Great pains are taken to keep these delicate appendages—so necessary to the life of the larvæ—from getting clogged, and, by the help of a lens, the larvæ can often be seen combing them out with their mandibles.

The life of a submerged insect in a rapid current has, of course, its own special difficulties, met with, as usual, by special adaptations. The *Simulium* larva has to creep from leaf to leaf to change its position as the stream rises and falls, and to avoid enemies. Of these enemies, Caddis worms are the commonest and most

formidable. In moving about there is always the danger of being accidentally dislodged; and if a larva should let go or miss its hold in a rapid stream, what is likely to happen? It seems inevitable that it would be swept away, and who knows where it would come to rest? Yet, as it will shortly be seen, the *Simulium* is quite safe.

"The little rivulet," says Mr. Miall, "which I am accustomed to visit for the purpose of observing this larva is a bright, clear stream, flowing over watercress and brook-lime, and forget-me-not. A few feet lower down it ends in the wide and stony Wharfe, a stream of quite different character, in which I have never been able to discover a single specimen of this species. Other brooks in which the larvæ are plentiful empty themselves into rivers unsuited to an insect of habits so peculiar—muddy, sluggish, or brackish. But this difficulty has been provided against, and I find that the larva is seldom or never swept away, even when its haunts are invaded by a groping naturalist. . . . If seriously alarmed, the larva lets go, and immediately disappears from sight. But by watching the place attentively we should, before long, see the larva making its way back, and in a minute or two it will be found attached to the same leaf from which it started, or to some other leaf equally convenient. . . .

"On close observation a thread, or perhaps a number of threads, become visible in the white ground. (Mr. Miall, for purposes of observation, had pushed a white plate in amongst the leaves, when the dark-coloured larva became perfectly evident.) These threads are, in general, stuck all over with small vegetable particles, like fine dust. The threads extend in all directions from leaf to leaf, and the larva has access to a perfect labyrinth, along which it can travel to a fresh place by help of the current, and with the speed of lightning. I suppose that it grasps the threads with its pro-thoracic claws, for when it comes to rest it is always found holding on by them. . . . Although the larva commonly slides along a thread previously made, and easily seen to be an old one by the small particles that cling to it, it can, upon a sudden emergency, spin a new thread, like a Spider or a Geometer larva. The new threads are perfectly clear and clean; they are therefore invisible on a white ground so long as the larva is submerged. . .

But by suddenly lifting out of the water a leaf with many larvæ upon it, one may get proof of the spinning of fresh threads. One or two are pretty sure to let go and drop a foot or more in the air, and the thread can be seen to glisten in the sun and to lengthen itself at the pleasure of the insect. The *Simulium* larva, gifted with this power of instantaneously manufacturing a rope, can hardly be taken at a disadvantage."

The salivary glands which secrete the silk are unusually large in this larva; they extend the whole length of the body, and then bend forwards for a third of its length. But the next question is as to how the safety of the pupa of *Simulium* is provided for; it seems that such an inactive, defenceless body must immediately be carried away to destruction by a rushing stream. The pupa is however as safe as the larva, being protected in a kind of nest, glued, somewhat like the nests of some swallows, to the stem of a

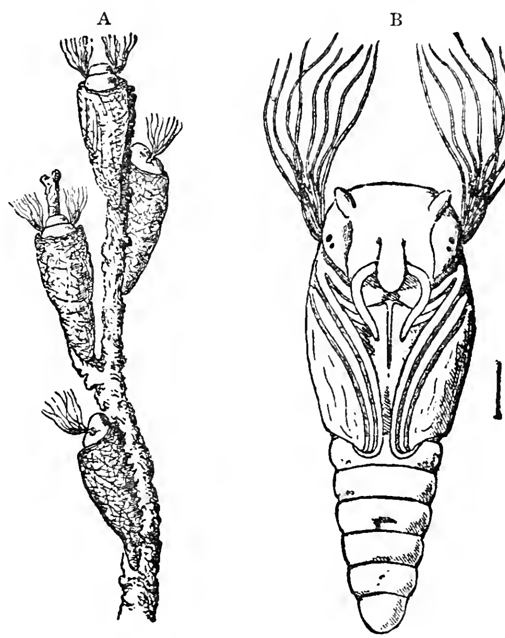


Fig. 6.—*A*, Four pupæ of *Simulium* in their cocoons attached to aquatic stem. *B*, Pupa of *Simulium*, removed from its cocoon.

water weed (Fig. 6). When the little nest is first formed it is completely closed; but when the insect has cast its larval skin, it knocks off one end of the cocoon, and thrusts the fore-part of its body into the current of water, whilst the hinder part is firmly

hooked to the silken threads with which the cocoon is lined. After the pupal stage comes the question as to how a minute gauzy fly can escape from the rushing water into the air. Through its elaborate respiratory appendages, the pupa draws in sufficient air to inflate its pupal skin ; this at the proper time splits along the back, and a small bubble of air emerges, rises quickly to the surface of the water, and then bursts. When the bubble bursts, out comes the fly. It spreads its hairy legs and runs upon the surface of the water to find some solid support on which it can climb ; and, as soon as its wings are dry, it flies to the trees or bushes overhanging the stream.

The ascent of the *Simulium* fly through rushing waters is rendered safe by the hairy covering of the body ; the surface-film clings to the fine hairs, and keeps the air imprisoned and the fly's body dry. In the same way a covering of velvety hairs prevents the Diving Spider, as well as many diving insects, from wetting that part of their bodies which bears the spiracles.

Few objects in natural history are more enticing to the imagination than the Dragon fly ; its etherial beauty, its gauzy wings, and jewelled body, make it seem hardly a thing of earth. Yet, alas ! further knowledge shows this spirit-like creature to be a merciless carnivore, its mouth filled with the little insects it stores up for eating at leisure. The ugly, sluggish larva of the Dragon fly is armed with one of the most murderous weapons it is possible to conceive. "The policy of the slow Dragon-fly larva is to lie still, in the shady recesses of water-weeds, till its victim comes within easy reach ; then, quick as lightning, it stretches out an arm-like extension of the head, and seizes its prey. The weapon so employed is a peculiar modification of a pair of limbs attached to the head, and called the second pair of maxillæ. In insects these appendages form the third pair of jaws, and are formed more or less completely into a labium or under-lip. The labium of the Dragon-fly is carried on a jointed arm, usually much expanded at the end. Side-pieces corresponding to the labial palpi are attached, and there is commonly a pair of spines or claws, which secure the struggling victim. When the larva is at rest the apparatus is folded up, the broad joint being spread over the front of the mouth, while the arm is bent backwards between

the fore-legs. In Libellulid larvæ, the side-pieces can be brought together in the middle line, like the jaws of a rat trap, which they further resemble in their toothed edges.

A number of aquatic insects, like the terrestrial Ichneumons, lay their eggs in the bodies of living insects. The larvæ hatch out and devour the bodies of their hosts little by little, delaying fatal injury till the parasite is full grown. "One such form, *Agriotypus*, preys upon caddis worms. . . The history of this parasite has recently been more fully explored by Klapálek.* In Bohemia, Klapálek finds that *Agriotypus* commonly attacks the case of a Caddis worm, known by the name of *Silo pallipes*. On warm days in April the *Agriotypi* may be seen swarming like ants about the banks of the brooks, and also flying above the water. The females descend stems and grasses into the water, and creep under stones in the bed of the stream in search of victims. The larva of the parasite spends its whole life under water and inside the case of a Caddis worm. Its host is not mortally injured till it has prepared for pupation. Like a healthy Caddis worm, it makes its case fast and closes it up. Then the *Agriotypus* larva makes a final end of its victim. devouring it, and cramming the remains into the hinder part of its case. It then proceeds to move the case by a long band formed from its own salivary glands, which is the external indication of an agriotypised Caddis." Within this extemporised cemetery it spins its cocoon, and winters before emerging as a winged fly (Fig. 7). A ghastly history, closely parallelled by that of the Sphex wasp.

The larva of the Alder fly, *Sialis*, is guided by one of those extraordinary instincts which suggest that the animal is directed by some intelligent power, to which one can ascribe wisdom, but not beneficence. The larva of *Sialis*, hatched under water, and living in water all through its early life, comes upon land in May or June to pass through its pupal stage. For this purpose it will travel far from its native pool. Mr. Miall says, "I have lately found one creeping on the surface of the ground six yards from the water, though the season was dry, and the soil common garden mould. This larva had climbed up a concrete wall, made its way through a thicket of cotoneaster, and reached an open flower-bed. When

* *Ent. Monthly Mag.*, 1889, p. 339.

the insect has found a place to its mind, it enters the earth, excavates a little cell, casts the larval skin, and is transformed into a pupa, which has the legs and wings free from the body, though

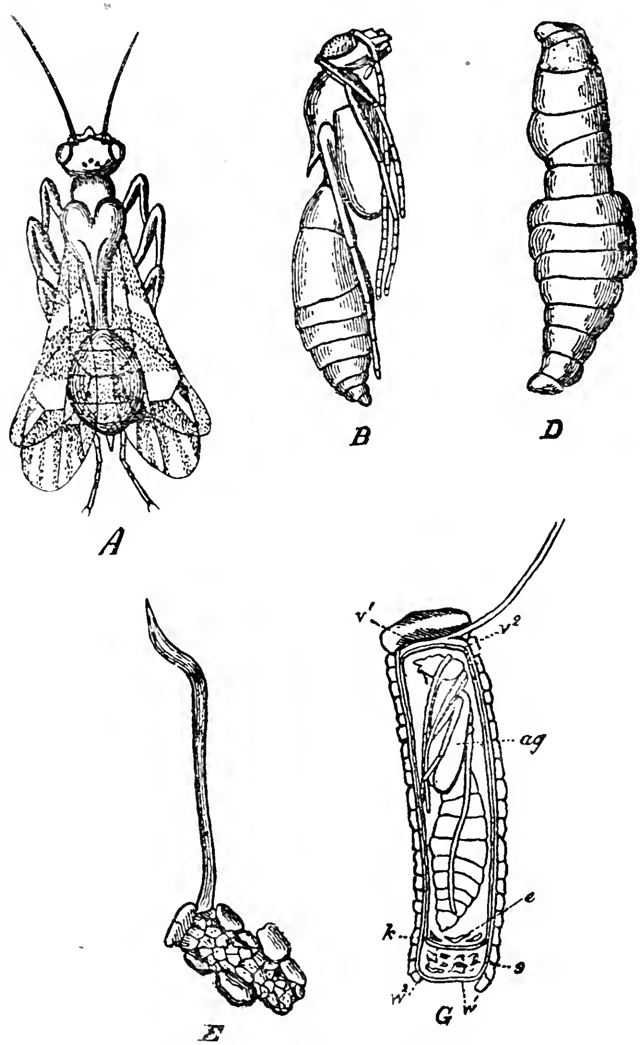


Fig. 7.—*Agriotypus armatus.*

A, Imago; *B*, Pupa; *D*, Larva; *E*, Agriotypised case of ditto; *G*, Section of ditto, showing—*v'*, Fore operculum; *w'*, Hind ditto of case; *s*, Remains of *Silo* larva; *a.g.*, Pupa of *Agriotypus*; *e.*, Remains of cast larva skin of ditto. From Klapálek.

enclosed in special sheaths. In about three weeks, a heavy awkward fly emerges, with black body and large coarse wings. The female lays patches of dark brown eggs on leaves, stones, or

palings, not far from water. When the larvæ hatch out, they travel to the water, and Mr. Miall says he has often seen the fresh hatched larvæ wriggling out on leaves many yards from the nearest stream or pond. "How they find the way," he adds, "I do not know," and that indeed is just the puzzle!

It would be impossible to condense, with any justice, the extraordinarily interesting accounts of the life-histories of *Ephemeridæ*, taken from the works of Swammerdam, Réaumur, De Geer, Sir John Lubbock, and other naturalists; but a few points of interest may be alluded to. The *Ephemeridæ* have, in their life-history, characteristics equally interesting and puzzling. Their lives as larvæ are comparatively long, and, in their aquatic stage, the creatures are provided with most beautiful and complicated feathery or leaf-like gills; they have no conspicuous pupal stage,* but undergo numerous moults, amounting in Chlocon to as many as twenty-one; they burst suddenly into aërial life, their wings expanding with such suddenness as to baffle the sight; the flat smooth eyes of the larval stage are succeeded by many-faceted, compound eyes, and two long tail filaments enable them to rise for their giddy flight over the water. All these complicated, exquisite arrangements lead up to a life of but a few hours—sometimes of only half-an-hour's duration; some species emerge at sunset, others after sundown; but all alike are destined to a rapid death, as in their perfect state they can take no food.

Réaumur fully describes his researches as to the emergence of *Polymitarcys*, the species of Ephemeron most common in the neighbourhood of Paris. He says: "In 1738, I resolved to attend to the emergence of this fly, and engaged an angler of Charenton to tell me when the first signs appeared, which were expected between St. Laurence's Day and Notre Dame d'Août, that is between the 10th and 15th of August. This year the flies appeared on the 18th. On the 19th I received warning from my angler, and the same day, three hours before sunset, I took his boat to examine the banks of the Marne and Seine. Where the shore was level and sheltered from the wind, heaps of dead *Ephemeræ* could be seen. During this excursion by water I removed some clods of

* See note, *Natural History of Aquatic Insects*, p. 305.

earth which were riddled with holes, and placed them in a large bucket of water. . . . The sides of the clods exhibited larvæ partly or completely exposed. At length the sun set. At that time *Ephemeræ* were to be seen flying here and there over the Seine. . . . I crossed over to the Marne, where there seemed still fewer. At about eight o'clock, the coming on of evening and the flashes of an approaching thunderstorm caused me to return into an arm of the Marne which washes my own garden. . . . Soon the man cried out that a prodigious number of *Ephemeræ* were coming. I seized one of the lanterns with which they had come to meet me, and ran to see what was going on. . . . I saw a sight beyond all expectation. The *Ephemeræ* filled the air like the snow-flakes in a dense snow-storm. The steps in my garden were covered to a depth of two, three, or even four inches. A tract of water five or six feet across was completely hidden, and as the floating insects slowly drifted past others took their place. Several times I was obliged to retreat to the top of the stairs from the annoyance caused by the *Ephemeræ*, which dashed in my face, and got into my mouth, eyes, and nose. . . . In about half-an hour, or less, the swarms were less dense, and by ten o'clock only a few scattered *Ephemeræ* could be seen on the river. Next day they appeared in undiminished numbers, and in diminishing quantities for four or five days longer." Réaumur speaks of changes of weather and of temperature, and says, "It appears that whatever the weather on the day of emergence—warm or cold—the *Ephemeræ* quit the water at a fixed hour.

"What becomes of the prodigious swarms of insects when they no longer fly through the air? They are for the most part already dead or dying. The fishes "enjoy a feast, and the French anglers speak of the *Ephemeræ* as *manna—e.g.*, they say the manna has begun to appear; there was a good fall of manna last night! Whether devoured by fishes or not, those that fall into the water soon perish. More lingering, but not less certain, is the fate of those which descend upon the banks in the neighbouring fields. Heaped one upon another, and unable to move, they die by inches." He speaks of the extraordinary rapidity of the act of emergence. As the wings are not provided with muscles, they are probably expanded by sudden injection of blood from the

heart. If the wings of an emerging larva are cut off and thrown upon the water, they will still expand; and the moult will be completed if the creature is thrown into spirit of wine.

It would be interesting to know the views of a May fly as to the nature of things. The Ephemeron which had seen the last departing rays of the sun, would be absolutely sceptical as to such an unverifiable phenomenon as sunrise; the Ephemeron emerging after sunset would certainly not be so unscientific as to believe in the existence of a sun at all. I imagine that our views as to the Universe must, to higher intelligence, appear as absurdly limited as would be the views as to earthly things of a philosophical May fly. Those scientists who declare that there are no phenomena in nature, and no natural laws but those which our very limited senses can comprehend, are, it seems to me, but as philosophical *Ephemeræ*.

Yet that brief life has in it something which, during its brief span, pleases us to dwell on. The long dull stage has been passed, and the insect emerges, with a swiftness that baffles the sight, into aërial life; then comes the giddy dance over the evening waters in the most delicious hours of spring and summer; then marriage flight, and the quick death ere night has passed. It is the Hellenic type of existence, all beauty, gaiety, and pleasure, with remorseless destiny awaiting the happy dancers. Destiny in the shape of swift skimming swallows and hungry fish.

I have had space in this article for only a tithe of the interesting life-histories to be found in Mr. Miall's fascinating book, and I envy those who are young and active enough to follow his example, and spend hours as he has done near some clear rushing stream, where watercress and forget-me-nots are growing, or by some quiet pool where little beings lie sucking the air-reservoirs of water-lily roots.

WE are deeply grieved to receive, at the moment of going to press with this sheet, news of the very sudden death of MRS. ALICE BODINGTON. She died on February 15th at New Westminster, B.C., Canada, of pneumonia, after an illness of scarcely five days' duration.

Staining the Tubercle Bacillus in Sections.*

SHERIDAN DELEPINE (*Med. Chron.*, 1896, v. 17) gives the following notes from the Pathological Laboratory at Owen's College:—The tubercle bacillus can easily be stained in section by the methods recommended originally by Ehrlich and by Ziehl. Many slight modifications in technical details have been introduced by a large number of workers, but the essential step by which the *Bacillus tuberculosis* can be differentiated from other bacilli consists in the use of mineral acids, such as nitric or sulphuric acid. When bacilli have been well stained with methyl-violet or with fuchsin, it is found that certain dilutions of sulphuric acid and nitric acid will rapidly remove the stain from all the known pathogenic bacilli, with the exception of the bacilli of tuberculosis and of leprosy, which are discoloured very much more slowly.

The use of nitric acid is, however, objectionable when one has to deal with delicate tissues, and even sulphuric acid, diluted with six parts of water, will cause a certain amount of distortion. For this reason bacteriologists have long wished to find a method which would be less brutal than those just alluded to.

Not long before his death, Dr. Kühne, of Wiesbaden, communicated to Dr. Borrel, of Montpelier, a method in which the use of strong acids was done away with. Dr. Borrel, after using this method in some researches in tuberculous lesion, has strongly recommended it in the *Annales de l'Institute Pasteur* (Vol. VII., p. 593).

In this method, after the sections have been stained in the usual way by means of carbolised fuchsin, they are placed for a short time in a solution of hydrochlorate of aniline, and after this they are left in alcohol till quite decolourised, when it is found that though the fuchsin has been removed from all the tissues, the tubercle bacilli remain deeply stained. This method, therefore, resembles very closely the Gram's method, with the difference that, instead of Gram's iodine solution being used to fix the stain in the bacilli, in this case it is Kühne's hydrochlorate of aniline which is used.

*From *Pediatrics*, July, 1896, p. 38.

Dr. Ratcliffe, being engaged in delicate experiments on the spread of tuberculosis in the laboratory, was advised to try this method, which seemed to present many advantages over the older methods, when a few bacilli only are present in the organ. The details published not being quite sufficient to obtain very satisfactory results in every case, we worked out the details now given, with the result that we can strongly recommend the following procedure :

(1) Fix tissues by means of perchloride of mercury, acidulated or not, and then harden in alcohol as usual.

(2) Embed tissues in paraffin, using toluol as a solvent.

(3) Fix sections on slides by means of glycerine albumen in the usual way.

So far, there is nothing new in the method.

(4) Stain with hæmatin solution for ten to twenty seconds to obtain a pure nuclear stain (not too deep) ; then wash thoroughly in water.

(5) Stain now with Ziehl's carbonised fuchsin, kept at a temperature of about 47° C. for twenty to thirty minutes. The slides are during that time to be kept in a moist chamber to prevent the stain drying on the specimen.

(6) Remove the stain, and treat the section with 2 per cent. watery solution of hydrochlorate of aniline for a few seconds.

(7) Decolourise in 75 per cent. alcohol till the section is apparently free from stain ; this will take from fifteen to thirty minutes.

(8) Double stain with a solution of orange (1 per cent. of saturated watery solution of orange to 20 to 40 parts of 50 per cent. alcohol).

(9) Dehydrate with absolute alcohol.

(10) Clear very rapidly with xylol.

(11) Mount in xylol and Canada balsam.

PENICILLIUM CUPRICUM.—Mr. J. de Seynes states that the fungus called by this name is but a form of *P. glaucum*, the ordinary appearance of which it assumes when transferred to a different medium.

The late Mrs. Alice Bodington.

(Abstract from Canadian Newspaper.)

THE citizens of New Westminster, B.C., Canada, were shocked this morning (February 16th, 1897) to learn the sad news of the death of Mrs. Bodington, the wife of Dr. G. F. Bodington, the Medical Superintendent of the Provincial Asylum for the Insane, which occurred on the 15th inst. Even the comparatively few who were aware of Mrs. Bodington's illness, from Pneumonia, had no idea of there being any immediate danger. In fact, her illness was very brief, scarcely five days, and no dangerous symptoms were developed until Sunday. All that loving care and medical skill could do was unavailing, and on Monday death released a noble soul from its bodily sufferings.

Mrs. Bodington, who was a native of Suffolk, England, and the daughter of the late Francis Capper Brooke, of Ufford, Suffolk, came to this province with her husband about ten years ago, and, after a short residence in Vancouver, B.C., they removed to Hatzic, where the doctor engaged in farming, in connection with a country practice. About two years ago, on receiving his appointment to the asylum, Dr. Bodington removed to this city, with his family.

In a comparatively short time, Mrs. Bodington made many friends in New Westminster, and helped on many a good cause. Besides being an energetic worker in Church of England circles, she was instrumental in forming a local branch of the Botanical Society of Canada, and was a warm friend of the Public Library and of the Art and Scientific Society, before which she read able papers on more than one occasion.

For many years Mrs. Bodington had been well known in the world of letters. Widely read, and a profound thinker, she wielded a strong pen, which was always ready to defend those principles of which she was so able an advocate. Among other works, Mrs. Bodington was the author of *Studies in Evolution and Biology*. She was also a regular contributor to such standard magazines as *The American Naturalist*, *The Popular Science Review*, and the *International Journal of Microscopy and Natural Science*, and we believe

that the very latest work of her pen appears in the present part of this Journal. Mrs. Bodington also frequently contributed vigorous articles on various subjects to the Provincial and local press.

Socially, Mrs. Bodington will be very greatly missed, while as wife and mother her death is a sad bereavement, and Dr. Bodington and his family have the kindliest sympathy of the community in their irreparable loss. Of the many children of Dr. and Mrs. Bodington, but two, Miss Winnie Bodington and a young son, are at home. Of the others, all grown up, one son is at Plymouth, another also being in England, one is a barrister in Paris, France, another physician on one of the Empress liners, and two daughters, Miss Bodington and Mrs. Hamilton, reside in Winnipeg.

Mrs. Bodington was buried at St. Mary's Church, Sapperton, on Feb. 17th. A large number of residents attended the funeral, amongst them being as many of the Asylum attendants as could be spared from their duties, six of whom acted as pall-bearers.

The floral tributes were numerous and very beautiful, especially one presented by the attendants of the asylum, by whom Mrs. Bodington was most highly esteemed.

A Review of the Golgi Method.*

BY OLIVER S. STRONG.

PART II.

" *Treatment and Preservation of Preparations.*

WHETHER the black stain has turned out so that the piece is worth keeping for further investigation can be ascertained by means of trial sections examined in glycerine, or in the reaction fluid itself. Then one must provide for the preservation of the piece and the microscopical sections. Although it is certain that a longer sojourn in the silver solution does no harm whatever, and that such a sojourn may serve as a means of preservation, yet it is expedient, in order to have the pieces ready for further treatment, to transfer them to pure commercial alcohol. This not only serves to harden the tissue farther, but also to free it from the silver nitrate which, as I shall mention below, is very

* From the *Journal of Comparative Neurology.*

injurious to the preservation of the microscopical sections. To accomplish the latter the alcohol should be changed two or three times till it remains transparent for a number of days after the piece is brought into it. In this way the pieces can be kept a long time. I have kept them for about nine years in this way, and can obtain from them, when I wish, preparations as clear as those obtained from them shortly after their preparation.

"The further treatment of the microscopical sections corresponds essentially with the usual procedure in obtaining anhydrous preparations, except for some peculiarities necessary to overcome some difficulties in the way of securing stable preparations.

"The sections, before they are permanently brought into gum damar or Canada balsam, must first be treated successively, according to the classical method, with absolute alcohol and some clearing fluid. Each of these steps requires an especial care not necessary with ordinary preparations.

"(*a*) *Treatment with absolute alcohol.* The only rule to be especially noticed here is that the sections must be very carefully dehydrated by bringing them into three or four changes of pure absolute alcohol. This is the only principal rule in order to obtain a long preservation, for the more accurately and carefully the dehydration is carried out, thereby freeing the tissue from the last trace of silver nitrate, the more one can rely upon the preparations remaining clear for a long time.

"(*b*) *Clearing.* The sections to be mounted must first be brought, for clearing, from absolute alcohol into creosote, where they remain some minutes, and then into turpentine. In the latter they can remain a long while. The selection of these two substances, and their consecutive use, is another aid to securing a long preservation. Among many other substances tried for clearing I have also found oleum origani* for my method very useful, but I have found no sufficient ground for abandoning the first mentioned fluids. The sections usually remain in turpentine only 10 to 15 minutes, but may remain there longer.

"(*c*) *Completion of the microscopical preparations.* For permanent preservation, the sections are brought from turpentine into

* This oil, followed by washing in xylol instead of turpentine, is preferred by the writer.

damar, which, after many comparative tests, I have found better adapted for this purpose than Canada balsam. I must here call attention especially to a peculiar treatment of the sections; contrary to the usual custom, I do not cover the preparations with a cover glass. When the sections are covered in the usual way with a cover glass, they begin after a time to turn yellow (owing to a second impregnation which takes place), then the outline of the stained cell elements become obliterated, the whole tissue becomes opaque, and, after a period of from two or three months to two years, the preparations, with few exceptions, become useless. On the contrary they may keep a long time, thanks to the repeated washing, of which I have spoken, and especially to the mode of mounting without a cover slip in a layer of damar. I can now state that the earlier lamentable disadvantage that preparations made by my method soon spoiled is now almost completely remedied. I have many preparations, made by me nine years ago, which have not yet lost their original clearness.

"If the good preservation appears menaced by an incipient yellowing, another longer bath, on the slide, in turpentine will restore transparency and freshness to the preparation.

"I have found it convenient to employ for this kind of mounting a special wooden slide with a square opening, in which, by means of a groove, a glass plate (a cover slip of somewhat greater diameter than usual) is fitted and stuck fast with a solution of shellac in alcohol. This serves as a slide, and the section adheres to it by means of the damar.

"This kind of slide not only enables the section to be examined from both sides, but also has the advantage of preventing dust from fouling the object, to which this kind of mount would be especially exposed. To accomplish this it is only necessary to turn the side of the slide with the section downwards, as soon as the damar is hard enough, or to pile the preparations on top of each other.

"I further remark that it is wise to shield the objects from the influence of light; still this precaution is not entirely necessary if the repeated washing has been carefully performed. After fulfilling these conditions, I might expose preparations for days to the sun's rays without injury to them.

"This is not the place to lay stress upon the value of the results which can be attained by means of this method. The figures accompanying this work demonstrate it sufficiently. They display the forms to be observed in the preparations with a fineness not only not exaggerated, but inferior to the natural object. I will here only bring forward the disadvantages of the method, in order to give the means by which they are to be avoided. The long time between the placing of the pieces in bichromate, and the appearance of the reaction (it not infrequently happens that, in consequence of this, the pieces are forgotten), the uncertainty about the extremely variable time required to reach the proper hardening, the different conditions in which individual layers of the same piece are found, all these are disadvantages whose removal would be desirable.

"I have sought by expedients to change my method in one way or another in order to secure greater certainty and accuracy in the results. Among the means tried by me I present the following which have yielded me a certain advantage.

"(*a*) *Injections of bichromate* (solution to 2½ per cent.)* It must be abundantly and constantly applied so that the whole parenchyma of the part to be investigated is fully and uniformly penetrated by the hardening fluid. The fixation of the elements by the reagent, where possible, before the slightest post-mortem change can take place is of the highest importance in securing a very delicate reaction. The action of the injection consists principally in giving a uniform hardening, furthermore in preventing, very likely, a slight post-mortem change in the interior of the piece, and finally in abbreviating the sojourn in bichromate.

"If I may draw a conclusion from some especially successful reactions accomplished in this way, I must declare that the injection is in these various respects actually of considerable advantage. Some other experiments, not yet very extended, have convinced me that a favourable influence is exerted in the same way by injecting, not a simple solution of bichromate, but one with gelatine added (2½ per cent. bichromate, 100 c.c.; dry gelatine, which is dissolved in the usual way, 5 to 6 grams). This proce-

* A stronger solution would probably be better, inasmuch as it undergoes dilution in the tissue.—*Author.*

dure appears to me especially fitted to give the pieces in less time that particular hardening most favourable to the best reaction with silver nitrate. I mention, for example, a case where I have obtained graduated reactions of surprising fineness on pieces fifteen to thirty days after they were placed in bichromate at a temperature of 15° to 20° C. (in autumn), the pieces having been subjected to the above treatment.

"The injection is performed in the usual way (with a simple syringe or with a siphon in which the pressure is regulated by the height of the vessel containing the injection fluid) either through the carotid, when one wishes to limit the hardening to the cerebrum and cerebellum, or through the aorta when the fluid should also extend to the spinal cord.

"It is superfluous to state that when the bichromate and gelatine is injected it must be warmed so that it will remain fluid. In this case it is especially important to perform the operation immediately after the death of the animal, before the tissues are cold. Only in this way does one secure the finest and most widespread injection.

"After the injection the nervous parts are removed from their cavities, cut into pieces, and brought as usual into bichromate, where they are carefully treated as dealt with above.

"*(b) Hardening in bichromate at a constant temperature.* The circumstance, pointed out several times, that the uncertainty about the time at which the pieces must be brought from the bichromate into the silver solution depends for the greater part upon the temperature of the medium, leads to the idea that the best means of avoiding this inconvenience would be the employment of a constant temperature for the bichromate in which the pieces lie. For this purpose the warm chambers used in investigations upon micro-organisms seem best adapted.

"I have used the chamber of Wiesnegg, in which I maintained a temperature of 20° to 25°. This had good success, but only in the direction of considerably abbreviating the period of hardening in bichromate, so that the reaction could be obtained much sooner than formerly and in a tolerably constant period of time. Thus, the reaction in a warm chamber appeared after eight to ten days and proceeded to completion up to fifteen to twenty days. This

is, perhaps, an advantage in so far as one can with sureness obtain certain preparations for demonstrations in a tolerably brief time. But the advantage is not extended to the fineness of the result, since in all such preparations the reaction turns out rather coarse. I was not thereby encouraged to extend experiments in this direction, especially as the abbreviation of the time can be attained in other simpler ways, and as the pieces in the chamber quickly pass by the period favourable to the success of the reaction without attaining the kind of hardening sought—which is a not insignificant disadvantage.

"(c) *Hardening in Erlicki's fluid* (bichromate of potassium, 2½ g.; copper sulphate, ½ g.; distilled water, 100 g.). Regarding this I confine myself to stating that the copper salt added to the bichromate did not prevent the reaction, and that the Erlicki's fluid possessed the same advantages and disadvantages as the preceding method (warm chamber). It accelerates the hardening so that in a few days (6 to 8 to 10) the black stain of various elements of the nervous system can be obtained by transferring to silver, but the result cannot be commended for fineness. Moreover the period advantageous for the reaction is very quickly passed over.

"As it appeared to me that the limited and not very fine form of the reaction might be due in part to the rapid action of the hardening fluid, I weakened the same by mixing it in gradually increasing quantities with Müller's fluid (Erlicki 20 to 50 per cent, Müller 30 to 50 per cent.). The results obtained by means of this variation were decidedly good. After only 5 to 6 to 8 days' immersion in such a fluid I obtained preparations which, in regard to fineness of result, had a certain worth. It thus appears to me that this variation can be recommended for the purpose of quick demonstrations of cell-forms. For the finest details, especially the relation of the functional processes of the ganglion cells and the nerve fibres, I find that the first procedure is always to be preferred, or also the following:

"2.—*Method of the successive actions of a mixture of osmic acid with bichromate and of the silver nitrate.* This procedure also is only a modification of the original, but deserves a place in the exposition as a method by itself, partly because the not unimportant

changes of the results which it yields and the treatment which it requires are to be ascribed to the newly-added reagent, partly because the process so modified can remedy some inconveniences of the original method.

"It can be applied in two ways, namely:—

"(*a*) By laying small pieces of nervous tissue directly in a mixture of bichromate and osmic acid (2 per cent. to 2½ per cent. solution of bichromate, 8 parts; 1 per cent. solution of osmic acid, 2 parts).

"The black stain is obtained the most quickly with this procedure. The black staining of a great number of nervous elements can be obtained by transferring into silver at the second or third day (see the directions for procedure in the description of the original method). The reaction extends itself on the immediately following days, then, as usual, diminishes, and at the tenth or twelfth day entirely ceases.

"The treatment of the macro- and micro-scopical preparations which are obtained in this way must be considerably modified. Pieces prepared by this method differ from those prepared by the first method inasmuch as when they are kept a long time, for future use, they become diffusely blackened, and thereby useless. They must be kept in the same silver solution which has served for the reaction. Then they are brought into pure alcohol, which must be changed, where they remain not longer than two days, sectioned and subjected to the above described treatment (absolute alcohol with repeated washing, creosote, turpentine, damar) necessary for their permanent preservation as microscopical preparations.

"Although this application of the osmium-bichromate solution is certain, and, as far as fineness is concerned, yields satisfactory results, yet I find that, for a systematic study of any definite portion of the nervous system, the following method is far preferable:

"(*b*) *Bringing of fresh pieces into the bichromate solution; first transference into an osmium-bichromate solution; second transference into the silver solution.* It is different with this second procedure than with the preceding, in which the series of pieces of tissue to be examined are useless after a few days. Here the fresh pieces (with or without injection) are laid in the bichromate solution, and remain, so to speak, in the hand of the investigator. They can

either immediately or later be tried, *i.e.*, during a period of from 3 or 4 to 25 or 30 days after the immersion. If one during this whole period transfers, at intervals of 2 to 3 or 4 days, some pieces into the osmium-bichromate solution, he thus possesses many secondary series of pieces which are brought singly (one or two at a time) into the nitrate solution. These, from the third or fourth to the eighth or tenth day of their sojourn in the mixture, yield with certainty, when brought into the silver, preparations with all the consecutive gradations and combinations described in the original method, and also possessing surprising fineness.

"*After-treatment.* Preservation of the pieces in the silver solution; pure alcohol for 2 or 3 days, till one has time to undertake the examination; repeated washing out of the sections with absolute alcohol; creosote, turpentine, damar, mounting without cover glass.

"This is the method which I at present prefer for the demonstration of the finest details in the structure of the central nervous system. The particular grounds for this preference are the following: (1) Certainty of obtaining the reaction in many gradations, if one makes use of a certain number of pieces. (2) The considerable length of time during which one can obtain the reaction —while one can also attain it in a few days. This renders an accurate investigation much easier. (3) The pieces are much more conveniently treated. (4) Finally, one obtains at the same time with the gentle gradation of the results also a greater fineness of the same, especially regarding the behaviour of the functional processes of the ganglion cells.

"3.—*Method of the consecutive actions of the bichromate of potassium and of bichloride of mercury.* This can likewise yield valuable results whose value is not diminished because they, in many respects, conform to those obtained by the silver nitrate. Indeed, the particular purposes it can fulfil, and its peculiar advantages, are in and for themselves so important that it must be given a place of its own alongside the silver nitrate method. The clearness with which the various elements of the nervous system emerge in this reaction is not less than that brought about by the silver nitrate. The elements appear, when viewed under the microscope by transmitted light, completely black after the action

of the sublimate, and for microscopical investigation the action is the same as when there is an actual black stain. But this stain is only an appearance due to the opacity of the elements upon which, probably owing to a reducing action, the mercury has precipitated. In reflected light one notices that the elements appear entirely white; indeed, under stronger magnification they show plainly a metallic lustre.

"I will remark that the particular advantages of this method consist first in the fact that the reaction can take place in large pieces, further that its success is absolutely certain without being necessarily bound by strict rules as to the time of sojourn in the hardening fluid, and finally in the fact that the preparations which it yields requires no especial precautions for their preparation, but can be treated in the usual way, like sections stained with carmine.

"The mode of application of the sublimate method is only distinguished from the silver method by some unessential things. It likewise consists of two essential processes:

"(*a*) Hardening of the pieces in bichromate.

"(*b*) Transference of the same into a solution of bichloride of mercury and sojourn in the latter.

"(*a*) The hardening in bichromate is done entirely in the usual way. (See the original method.) I only add that the reaction does not proceed in an essentially different manner if consecutively stronger solutions of 1, 2, 3 per cent. are employed, or if the pieces are immediately laid in Müller's fluid. In general it is expedient for the pieces to be small, but this is not absolutely necessary. Good results are also obtained with large pieces, indeed with whole brains. In the latter case the preserving fluids require a long time to penetrate by osmosis from the periphery into the interior, and the central portions could spoil before they experienced the action of the fluid. It is necessary therefore to make a careful preliminary injection of bichromate solution, so that the reagent is well distributed throughout the organ.

"A few days' (6 to 8 or less) sojourn in the bichromate solution is sufficient to obtain, by putting the pieces into sublimate solution, an extended fine black stain of a greater or less number of cells (indeed one can obtain an indication of the reaction on the fresh brain which is placed immediately in the sublimate solution). A

more suitable period to obtain fine and extended results is from 20 to 30 days. A much longer hardening (from 2, 3, 4 months, or more) is by no means unfavourable for the reaction. I remember, among other cases, to have obtained reactions of wonderful fineness in some whole brains which were in bichromate solution nearly a whole year.

" It will be perceived that this indefiniteness of the time constitutes a very advantageous circumstance, since thereby pieces can be employed which would otherwise be useless.

"(*b*) Transference of the pieces into the sublimate solution. The solution used by me contains ½ per cent. of bichloride of mercury. I have satisfied myself that the method is equally successful when the solution is weaker (¼ per cent.), or stronger (1 per cent.). The pieces are brought immediately from the bichromate into this solution.

" The reaction throughout the thickness of the piece results much more slowly than with the silver nitrate. If the pieces are suitably hardened, 24 to 48 hours suffices with the latter. With the sublimate, on the other hand, not less than 8 to 10 days are necessary, in order that the reagent may penetrate throughout the piece when the pieces are small, and much more (2 months and upwards) when the pieces are large (whole brains). The period of action of the bichromate must also be considered; the longer this has been, the longer must be the sojourn in the sublimate, but the more complete and delicate is the reaction.

" During the sojourn of the pieces in the sublimate solution, the bichromate with which the tissue is saturated diffuses out and impairs the purity of the fluid, which assumes a yellow colour, while the pieces become paler. For this reason the sublimate solution must be changed daily, especially at the beginning of the immersion. Later, the changes are made only when the solution becomes yellow.

" It may be assumed that the reaction begins when the pieces are entirely decolourised, *i.e.*, when the tissue is completely freed from bichromate. If, beginning about this time, sections are made and examined under the microscope daily, it will be noticed that the first traces of the reaction begins 3 or 4 days after the immersion, and that they can be known by a number of small black

spots scattered here and there. After 4 or 5 days more one sees the cell-forms gradually become more complete and numerous, and the reaction thenceforward continues to extend and complete itself. It even appears that further advantages are gained when the sojourn in the sublimate solution is extended indefinitely, the sublimate being changed as often as it becomes yellow through the presence of bichromate. With brains which have been long exposed to the action of the bichromate,—and such often yield the most beautiful results,—the sublimate solution must be changed during several months before this yellowing ceases.

"The above constitutes a further difference from the manner of action of the silver nitrate, inasmuch as in the latter the whole action is completed in 24 to 48 hours, after which no further action is exerted, although the pieces can be kept in it longer.

"When the reaction has reached its maximum, the pieces remain colourless, and have the appearance of fresh brain tissue which has been slightly washed in water.

"The pieces may remain in the sublimate solution as long as one pleases, not only on account of the possibility of a further extension of the reaction, but also because they thereby receive a hardening better adapted for making fine sections.

"As to the manner in which the reaction extends to the different elements, I will merely remark that the reaction affects the ganglion cells in pieces which have reached that degree of hardening attained in the first month's immersion in bichromate, and the reduction only extends itself gradually to the nerve fibres also. The reaction displays itself to the fullest extent in the nerve fibres almost exclusively in pieces which have lain a long time in bichromate, and are very strongly hardened. I recall in this connection the brains which have been kept very nearly a year in bichromate; they showed an almost universal very fine stain of the bundles of nerve fibres, and of their finest subdivision.

"*Treatment and preservation of microscopical preparations.* The only special precaution required by preparations made by means of the sublimate reaction before they are mounted in glycerine or balsam is a careful washing in water. Without this precaution a precipitate in the form of a black powder or needle-shaped crystals is formed in the sections some days after mounting,

and if it does not entirely spoil, yet seriously mars them. As to the rest, the usual mode of preparation is employed: mounting in glycerine, damar, or Canada balsam, after the necessary dehydration in absolute alcohol, and clearing in creosote or clove oil. No further precaution is necessary.

"When I described this method the first time* I expressed the conviction that it could be still further perfected so as to yield finer results than those hitherto attained by me. Practice has later led me to some modifications which have improved it. But it has experienced another important development owing to the persevering experiments of Dr. Mondino, who succeeded in applying the process with remarkable success to nothing less than a whole human brain. I will here add the words themselves in which this observer summarises the advantages whlch one can gain from the use of the bichloride of mercury for the study of the central nervous system.

"The following is Dr. Mondino's Summary †:

"'A. The sublimate method is the first by means of which we can obtain the black stain of the nerve cells and their functional processes in the entire brain, and enables us to follow these latter directly in their course through the brain.

"'There is no doubt but that this technique fulfils the requirements of scientific accuracy better, and puts us in a better position to obtain precise knowledge of the so-much debated course of the fibres in the brain than all the methods hitherto tried. At the most one could only, with the aid of the latter, see whether numerous functional processes, collected into bundles, proceed in certain directions, but with our technique one can examine them fibre by fibre and follow their anastomoses.

"'B. In all other methods we must, in order to obtain consecutive series of brain sections, bring the individual sections into vessels with the staining fluid. As one cannot provide so many vessels with fluid unless he possesses unusual means, several

* Camillo Golgi, "Di una nuova reazione apparentemente nera delle cellule nervose cerebrali ottenuta col bichluro di mercurio."—*Archivio per le Sc. Med.*, Vol. III.

† Mondino, "Sull'uso del bichloruro di mercurio nello studio degli organi centrali del sistema nervoso." Communic. fatta alla *R. Acad. di Medi di Torino nella Seduta* del 2 Genn., 1885.

sections must be brought into one vessel, and can therefore only be enumerated by groups, and not singly. By the method here described this result can be attained with great ease.

" 'C. In the other methods the sections must be very thin, and are liable to be torn in the various manipulations (from the microtome into the staining fluid, then to the slide, etc.). As the sections are very thin, they must be also much more numerous when a whole brain is sectioned; hence greater expense, loss of time, and more labour in making the preparations. In our method the sections need not be thin, they are therefore less numerous and exposed to fewer risks; whence little danger of losing sections, slight expense in the preparation, and greater rapidity in the preparation of a whole brain.

" 'D. Finally, one must use in all other methods, dyes, commercial and absolute alcohol, and clove oil or turpentine, while we employ a little sublimate and creosote, which are very cheap and inexpensive. In the other methods we must use cover slips, because the high magnification which they require—and then one does not see much—would not be applicable with the thick layers of damar. We do not require this, and thereby escape not only expense, but also the difficulty of avoiding bubbles of air under large coverslips, whereby the preparation is often endangered.'

" It appears to me, apart from all economy of material, time, and labour, as well as the convenience of cutting pieces in the microtome so to speak at odd moments without injury to them from the long contact with water, that this method, which enables us for the first time to follow in sections the course of nerve fibres through the whole brain, shows an advance in the technique of the study of the central nervous system, and takes precedence over all others.

" As I pass over the application for the macroscopical study of the brain which Dr. Mondino has also made of this method, I will here in conclusion again assert that the sublimate method takes a high place among the microscopical methods for the study of the nerve centres, alongside of the methods in which silver nitrate plays the chief rôle."

Additional technical notes in Golgi's method, " Das diffuse nervöse Netz der Centralorgane der Nervensystems. Seine physi-

ologische Bedeutung" (from the *Rendiconti des R. Instituto Lombardo*, Ser. II., Vol. XXIV., Fasc. 8 and 9), pp. 259 and 260 of the German edition of Golgi's works :

"The Method which was most useful to me in the investigations described in the first part of this work, was the staining of the nervous elements with mercury sublimate, but with a modification which enhanced its demonstrative value without changing the fundamental procedure. The latter consists (1) in the hardening of the pieces in bichromate of potassium ; (2) in the transference from this into a ½ per cent. to 1 per cent. solution of bichloride of mercury.

"Since I have given in another work ('Studi sulla fina anatomia degli organi centrali del sistema nervoso,' p. 202) a detailed description of what I call the fundamental part of the method, I consider it fitting to add that the best and finest reactions in the nerve fibres and the interstitial diffuse network was observed by me in pieces (from the spinal cord of the new-born kitten) which had lain a long time (in part over two years) in a 1 per cent. solution of sublimate, after a long preceding sojourn in a bichromate solution (first, Müller's fluid ; then, pure bichromate to 3 per cent.). Since they were pieces which had lain in the laboratory in this way ready for examination but had not been used, I can, naturally, not tell what influence the long sojourn in the sublimate may have exerted.

"The modification introduced by me, to which I must attribute a certain value for the clear demonstration of fine details, and to which I call the attention of the observer, consists simply in a slight addition, viz., the blackening of the glistening white stain which the nerve elements receive by means of the mercury impregnation.

"As is known, the elements treated with sublimate appear black in transmitted light, on account of the opacity caused by the reaction, but in reflected light they appear white. This difference may be easily observed by turning off the mirror of the microscope.

"This kind of appearance is satisfactory for observation with low or medium magnification, where less fine details are concerned, but it is otherwise with the finer details, where stronger magnifica-

tion is required. In this case the metallic lustre of the fine parts, *e.g.*, the finest divisions of the nerve fibres, evidently affects the observation unfavourably by giving the pictures a certain indistinctness. The black stain which replaces the white-metallic brings out better the outlines of the fibres, and so increases the demonstrative value of the preparation.

" Inasmuch as the impregnation consists of metallic mercury, the transformation of the metallic white into deep black can be accomplished, according to the teaching of elementary chemistry, by means of a number of reagents. There can serve for this purpose: the sulphite and hyposulphite (particularly sodium sulphite and hyposulphite in 5 per cent. solution), the sulphide (of potassium, sodium, and ammonium, the first two in 1 per cent. to 2 per cent., the third in ½ per cent. solutions), sulphuretted hydrogen (one part of the saturated solution and three parts of distilled water). One can also use with advantage the sulphocyanide (of potassium, sodium, ammonium, in 2 per cent. solutions).

" The solutions of sulphite and hyposulphite, especially the second, render necessary a careful watching of the preparations that they are not entirely destroyed through a disappearance of the metallic impregnation.

" The sulphides (of potassium and sodium) are easier to manage, but the complete preservation of the preparations is not entirely certain with them.

" The sulphocyanide acts very well in bringing into view the smallest parts upon which the metallic impregnation has acted, but it does not give a uniform black, only a brownish stain. Besides this the cells and fibres under the action of this reagent assume a punctate, almost pulverulent appearance.

"Sulphuretted hydrogen is very disagreeable on occount of its offensive smell (a peculiarity which it has in common with ammonium sulphide), and it also has a tendency (as has the ammonium sulphide) to stain those parts containing no sublimate brownish, which impairs very greatly the clearness of the preparation.

" From all these grounds, and, particularly on account of its rapidity and certainty of action, on account of the intensity, uniformity, and sharpness of the black stain obtained, and on account of the certain permanency of the preparations, the mixture used

by photographers to stain and fix their pictures upon aristotype paper is to be preferred to all other substances given here (naturally for the special purpose of the treatment of the sublimate preparations).

"From the many formulæ of this kind which are found in books on photographic technique, I have adopted one which I repeat in a footnote.*

"The modification which I have adopted with my sublimate method is as follows:

"The pieces which have been proven to be successfully impregnated are embedded in celloidin in the usual way and cut with the microtome. The sections are then subjected to the following treatment:

"(1) Washing in distilled water.

"(2) Immersion one or two minutes (they can also remain several minutes without injury) in the above fixing and staining fluid. Several cubic centimetres of the fluid suffice for many sections. The blackening can be observed with the naked eye.

"(3) Careful washing in distilled water.

"(4) If desired, light carmine stain to bring out the cell bodies and nuclei in the fine interstitial nervous network. Acid carmine is best adapted for this, according to my experience, and I find especially suitable a dilution of this staining fluid with acetic acid and alcohol (equal parts). The fluid into which the sections are brought must have a deep red colour.

"(5) Repeated washing in water, and then successive transference into alcohol and clove oil, and finally mounting in Canada balsam or damar in the usual way.

"Preparations treated in this way possess, besides the above-mentioned advantages, the additional one that the fine powdery

* For toning the two following solutions are separately prepared:

(*a*) Water, 1 litre; Sodium hyposulphite, 175 g.; Alum, 20 g.; Ammonium sulphocyanide, 10 g.; Sodium chloride, 40 g. This mixture stands quiet for 8 days, and is then filtered.

(*b*) Water, 100 g.; Gold chloride, 1 g.

To prepare the bath one mixes of solution (*a*), 60 ccm.; of solution (*b*), 7 ccm.; old, combined bath, 40 ccm. For economy and convenience I use fluid which has also served for toning, thus for this purpose almost useless.

precipitate does not after a while appear. This precipitate almost always, if there have not been previous repeated and long-continued washings, at last spoils the preparations prepared according to the original method."

The Preparation of Blood for Microscopical Examination.*

IN a recent number of the *Medical Record*, Dr. Henry G. Piffard alludes to a branch of blood examination, which, he says, is exciting at the present time an increased and well-merited interest. This is the preparation and examination of blood spread in a thin layer and dried on cover glasses.

Blood films are studied from several standpoints and with several distinct objects in view. These are chiefly: To determine the presence or absence of malarial plasmodia; to ascertain the presence or absence of the eosinophile, neutrophile, or basophile granules of Ehrlich; to observe changes and abnormal appearances in the leucocytes and red corpuscles; and to determine the presence and kind, or absence, of micro-organisms. In all these cases the manipulation is substantially the same, with the exception of the stains to be employed. It is this technique, he says, which he desires to describe in the fullest detail, and with special reference to the slide, the glass cover, the needle, the forceps, the spreading of the film, the fixing and dehydration of the corpuscles, the staining, the mounting, and the optical apparatus, and especially the condenser and objective.

He states that the most satisfactory slides he has been able to obtain are those furnished by Zeiss, at three and a half marks a hundred. These are cut true to size (seventy-six millimetres by twenty-six millimetres), are of good glass, and are easily cleaned for use with a drop or two of alcohol and a piece of Canton flannel. Zeiss also supplies slides of plate glass at double the price mentioned, but these it is almost impossible to clean with either alcohol or acid. The slides chosen should be of medium

* From the *New York Medical Journal.*

thickness. Very thin ones were formerly of service when attempting difficult resolution with extremely oblique mirror illumination. With a substage condenser, however, extreme thinness of the slide is not only unnecessary, but undesirable, especially in high-power work. The majority of modern microscopes that are pretended to have any degree of excellence are provided with substage condensers, either N.A. 1 achromatic or N.A. 1·20, or 1·40 Abbé.

Now, these apertures are possible only when there is a layer of cedar oil between the condenser and the slide. The principal microscope makers list their condensers as having the apertures mentioned, but not one of them, so far as he is aware, has the honesty to state that these apertures exist only when they are used with oil immersion, and that when used dry, as is usually the case, the numerical aperture is very much less. If, now, the observer desires to employ an immersion objective of high aperture and to work it at its best, he must put oil on the condenser and focus it for critical illumination. If the slide is an exceedingly thin one, in bringing up the condenser to keep the oil in position, he will project the flame image above the plane of the object under examination. If the condenser is now depressed so as to make the flame image coincide with the object, the oil is apt to run out, especially if the microscope is inclined. The condensers are constructed to work with slides of medium thickness, and such slides are the only ones that should be used.

Cover-glasses should be selected with great care. Square ones should never be used in the preparation of blood films, because it is exceedingly difficult to obtain a good smear, and it is almost impossible to mount them in a satisfactory manner for permanent preparation.

The most convenient size of round glass will be either three-quarters of an inch or eighteen millimetres. American dealers supply the covers in four grades, according to thickness—namely, Nos. 0, 1, 2, and 3. The first two are altogether too thin for general use, and should not be used under any consideration. A great deal of blood work can be done better with dry lenses, and the non-adjusting dry lenses in common use are corrected by their makers for a certain definite thickness of cover-glasses; and if a thinner one is used, the image obtained will be imperfect. The

cover-glass thickness will be found, therefore, to play an important part in blood examinations.

The next step, continues the author, is the proper cleaning of the covers. A small glass dish should be partly filled with battery fluid (water, nine ozs.; bichromate of potassium, one oz.; sulphuric acid, one oz.), and into this the covers should be dropped, one by one, so that both sides of the cover may be wet by the fluid. After remaining in this for twenty-four hours, the acid is poured off and the covers are flushed *en masse* two or three times with water. Then each should be taken separately and dropped into a dish of distilled water, from which they are to be transferred, singly as before, to alcohol (preferably pure methylic). A most convenient receptacle for the alcohol and covers is a one-oz., square, screw-capped bottle, in which they may be kept until needed for use.

A very convenient instrument for drawing the blood is a small, straight, surgical needle, several of which should be kept in a phial of alcohol until needed. For two years or so he has used needles made from an alloy of one part of iridium and two parts of platinum. When required for use, the needle is sterilised at a white heat immediately before and also after use. The blood may very conveniently be taken from the tip of the finger, though some writers insist that it is better to draw it from the lobe of the ear. In either case the part should be thoroughly cleansed.

Two forceps are required. One should be of the self-closing variety, with flat, broad points, and with a spring sufficiently stiff to hold the cover firmly against moderate traction. The other may be of any sort that will hold the cover nicely.

A sufficient number--say six or eight—of the covers are removed from the alcohol, thoroughly dried, and laid upon any suitable support, projecting a little beyond it. One of the covers is seized with the self-closing forceps and placed ready at hand. The puncture is then made, and another cover is quickly taken with the second forceps and applied to the droplet of blood as it issues from the wound. The second cover is then laid on the first, and the blood spreads out between them. A common fault with beginners is taking up too much blood; but this will be corrected after a little practice. As soon as the film is spread, the projecting edges of the upper cover are taken between the thumb

and the index finger, and the covers are gently slid apart, care being taken to keep them parallel until they are entirely separated. The two covers, with films up, are now laid on a piece of paper to dry, and a second pair are prepared in the same manner. If more than four covers are desired, a fresh puncture should be made. As soon as the films are dry, they may be placed in a small envelope and properly labelled. If they are stored in a dry place, they will remain unchanged for a long period. It is better, however, to fix them immediately. If water or any staining fluid was to be applied before fixing, most of the corpuscles would be washed off the cover, and from those that did remain the hæmoglobin would be removed, leaving only the invisible stroma.

With regard to fixing the corpuscles, says Dr. Piffard, the best method, and one which his own experience leads him to prefer, is with heat rather than any of the other methods that have been employed. For the past year, for this purpose, he has used an electric heater controlled by a rheostat. The covers are heated gradually to about 225°F. and then maintained at this for an hour or more. When the covers are taken from the oven, they are allowed to cool gradually and thoroughly before staining.

When ready to stain the covers, they are placed film up on a plate of glass, and covered each with the eosin solution. This is left on for two or three minutes, and washed off with distilled water. When the covers are dry, the methylene-blue solution is applied in the same manner; and when this is washed off, and the covers are thoroughly dry, they are ready for preliminary examination.

The microscope is arranged vertically, with a clean slide on the stage, and the cover is placed on it, film down and without any intervening medium. Alongside of it, if it is desired, another cover is mounted in balsam and the two are compared. The difference between the two is so striking and absolutely in favour of the dry cover that Dr. Piffard thinks the balsam would be rejected for this purpose. This examination must, of course, be made with a dry lens. A No. 7 Leitz answers very well, but an eighth of an inch or a tenth of an inch objective, with a numerical aperture approximating 0·90, is still better.

If the examination with the dry lens does not give all desired

information, and a further examination is desired with a higher-power immersion, it will be necessary to attach the cover permanently to the slide.

If blood covers are to be mounted to the best advantage, the first step is to procure a turn-table. The slide is carefully centred on this, and a thin ring of shellac or other suitable cement spun, corresponding to the size of the cover; a second coat may be applied a few minutes later. A number of slides are prepared in this way, and left for twenty-four hours or more to dry.

When the slides are ready for use, one is taken and held over a flame for a moment or two to expel all surface moisture and to soften the cement a little. The cover in like manner should be flirted over the flame, to expel all moisture from its surface. It is then applied to the cement ring, care being taken to have contact at all points of the circle. When entirely cold, a fresh ring of cement may be spun around the cover, so as absolutely to seal it at every point. The slide is now ready for examination in any manner, and with any dry or immersion lens.

It matters not, says the author, whether we are studying the changes in the leucocytes, hunting up the various granules of Ehrlich, or searching for the elusive plasmodia, the optical picture will be vastly superior and much more instructive than any we can obtain in balsam mounts.

In regard to the substage condensers, he continues, if circumstances restricted him to the use of a single condenser for all purposes, he would choose an achromatic N.A. 1, which may be obtained of excellent quality from Zeiss, Bausch and Lomb, Watson of London, and other makers, costing perhaps ten or twelve dollars more than the customary Abbé. With dry lenses, except those of the very widest aperture, it should be used dry—that is, without oil between the condenser and the slide. By so doing the nominal aperture will be impaired about a third and thrown a little off its corrections; but even then it will be better than any of the Abbé construction. If used in connection with immersion lenses, oil contact should be used so as to secure the full aperture. If circumstances permit the expenditure, an additional achromatic of N.A. 1·30 to 1·40 should be added; and for low-power work, an achromatic of low aperture—say, N.A. 0·60 to

0·75. In regard to the Abbé condensers that are in such general use, it may safely be said that they are a vast improvement on simple mirror illumination, that was almost the sole dependence before Professor Abbé introduced his simple device. The low cost has undoubtedly been the chief means of its wide introduction, but as an optical instrument of precision it is decidedly inferior to an achromatic of approximate aperture.

Through force of circumstances, fully nine-tenths of the laboratory workers employ diffuse daylight as an illuminant, and for the great mass of work to be done it is amply sufficient and satisfactory; but for the most delicate work a well-arranged artificial light is preferable.

At the present time, says Dr. Piffard, the blood offers one of the most inviting fields of investigation, as an aid both to diagnosis and to therapeutics; and he strongly urges on those who design to take it up to pay the strictest attention to what at first may appear to be unimportant technical details.

Selected Notes from the Note-Books of the Postal Microscopical Society.

Anatomy of Diptera.

By W. Jenkinson. Plate IX.

PERHAPS the slides circulated herewith will interest only a few members of the Society, but from those few I ask fair criticism and kind suggestions where difficulties occur. Except in Classification the English Flies have had but scant attention. We know comparatively little of the life-history of these common insects; certainly the Rev. J. G. Wood has done something towards making a few species popular, and Mr. B. T. Lowne has given us his Monograph on the Anatomy and Physiology, yet the subject is far from being exhausted.

Sections of the Tarsus and Pulvilli of Sarcophaga carnaria (Pl. IX., Fig. 1), stained with borax-carmine. In this fly the pulvilli are abnormally large, and for that reason I have chosen it.

The upper wall of the pulvillus is composed of chitinous semi- or half-tubes directed lengthwise, and joined together at their edges, thus forming a very flexible roof. The lower surface is clothed with fine tapering, unpigmented hairs; these hairs are commonly said to be hollow, but I have searched in vain to find a lumen in them. In some species the hairs are trumpet-shaped—*e.g.*, in those of the Gad-fly and a parasite from an Indian bat.

Common with the pulvilli of other flies, I find they contain glands, but neither muscle nor nerve. The sections under notice are very rich in glands, which evidently elaborate the viscid fluid by which the fly is enabled to walk in an inverted position on the ceiling or on glass. Here we meet with a difficulty. If the hairs are not hollow, and there are no openings in the lower wall near them, how does this viscid fluid get on to them? I shall be glad of any suggestions on this matter.

It has occurred to me that, beyond the circumstance mentioned above, the viscid fluid may fulfil a much higher purpose to man and other animals. In flies which deposit their eggs upon decomposing and often diseased animal matter, but do not feed upon such matter, the fluid would entomb any disease-germs taken up by their feet—that is, supposing the fluid hardens on exposure to the air like the fluid emitted by the spinnerets of spiders and the larvæ of some Lepidoptera. I do not wish to imply that flies do not disseminate disease-germs. This, I believe, is frequently done when they feed on fluids containing such germs, by carrying them on their proboscis to pure fluids, on which they afterwards regale themselves.

Hilaria pilosa, Longitudinal section of the Tarsus of Male.—In the male insect the first joints of the anterior tarsi are greatly enlarged. In this section the most prominent feature is the numerous large glands with their ducts; the apodéme, which moves the joints, the nerve, and tracheæ, are also shown, whilst no muscle is visible. The ducts penetrate the inner wall of the joint, and the outlet can be seen in one of the sections.

The purpose of the secretion from these glands is, in all probability, the same as those in Water-Beetles, where the glands have their outlets in both the large and small discs on the anterior feet.

Head of Blow-Fly (three transverse sections).—From the amount of loose embryonic cells seen in these sections, it is evident that the fly had but recently emerged from the pupa case.

On the first of these slides are numerous portions of the brain and optic tract, and as they are fairly thin (about 1/80 mm.) most of the recent discoveries may be compared with them. M. N. Newton states in the *Magazine of Natural History*, 1879, p. 397: "In the cerebroid or supra-œsophageal ganglia are situated the organs of perception, of memory, of intelligence, etc. Hence they have a more complicated histological structure than the sub-œsophageal ganglia which principally govern the appendages of the mouth. These nerve-centres are nevertheless constructed on the same general plan as the other ganglia. In the middle they present bundles of nerve-fibres, while the nerve-cells principally occupy the periphery."

In these sections nerve-fibres may be traced from the centre of the œsophageal ganglion to well-defined peripheral nerve-cells. There is here a likeness to the Vertebrata, though in almost every other respect, with the exception of the muscles and nerves, we find the opposite.

The compound eye and optic nerve has been so well worked out by Hickson, that I would refer our friends to his paper which appeared in *The Quarterly Journal of Microscopy*, No. XCVIII. In Fig. 2 I give a tracing from this paper, showing one facette of the eye and with it terminal fibres, etc.

The second slide shows several sections through the frontal sac. Lowne believed this to be an olfactory organ, adapted to the appreciation of powerful odours. If we look at the head of the insect as an almost closed sac, bounded by rigid walls, and with all otherwise unoccupied spaces filled with a circulating fluid (the blood), whose communication with the thorax is by a very small neck, and that small space taken up by the œsophagus, nerve-cords, and tracheæ, it is evident that the blood could not pass so quickly into or out of the head as would admit of the quick protrusion of the proboscis (see Fig. 3). Hence, in the frontal sac there is a beautifully simple contrivance well adapted for such a purpose. It is a simple sac suspended near the upper wall of the head, with the wider surface hanging in numerous folds. The sac

is in free communication with the outer air through an opening in the forehead immediately above the antennæ. The outer surface is covered with numerous papillæ. When the folds are brought so close together that the papillæ interlock, they always enclose some air, thus preventing any adhesion of the surfaces, which might be the case if the surfaces of the folds were smooth and moist. By this means an equable pressure is maintained on the brain and other organs. Some years since (1887 or 1888) I read a paper before the Sheffield Microscopical Society on the "Frontal Sac." This was published in *Science Gossip* without my consent and consequently without my signature.

The third slide shows sections of the antennæ. These sections are mostly cut through the second and third joints, the first joint not being in the same plane. Exteriorly the third joint is covered with two kinds of pigmented hairs. The finer and smaller appear to be nothing more than clothing; but the larger ones are hollow, their lumen continuing through the chitinous wall of the joint. Epithelium lines the interior of the joint, the ends of the cell being drawn out, and projects into the lumen of the hairs. This is distinctly seen in thin sections, in which the epidermis became somewhat detached from the epithelium during the manipulation of the section. From the nerve numberless fibres are seen to enter the epithelium lining, but I have been unable to trace them any further.

By using a more suitable stain, the nerve-fibres may possibly be traced through the epithelium, or the epithelium may be endowed with the same conducting power as the nerve-fibre. From this rich supply of nerve matter, it is pretty clear that the large hairs must be the seat of some sensation, but what sense they represent is very difficult to prove by experiment, because another sense-organ is intermingled with them. It is highly probable that these are tactile organs, though this term is very vague, for it implies the sensation of either cold or heat, humidity, or touch, etc., and for this reason I am of opinion that further proof is still required.

The most highly developed tactile hairs are those on the lobes of the proboscis, where they end in a large bulb in immediate connection with the nerve. By their position they are undoubtedly

organs of touch, and may be seen very distinctly in a vertical section of a well-distended proboscis (see Fig. 4).

Another feature well developed in the third joint of the antennæ of the Blow-fly, and many of the other domestic species of flies, is a somewhat spiral organ covered on the exterior with fine impregnated hairs; these hairs penetrate the wall of the organ, which is also lined on the interior surface with epithelium and receive a rich supply of nerve-fibres. It is computed that there are about eighty of these organs in the one antenna of the Blow-fly, and from their position, and the well-known highly developed sense of smell possessed by this insect, there can scarcely be a question but that they are olfactory. The extreme paucity of these organs in other species of different habits strengthen my convictions on this subject. Among these are the common Dung-fly, *Eristalis tenax*, *Rhingia rostata*, and a host of others.

Eristalis tenax, longitudinal section of haltere.—For convenience of examination the haltere of the fly may be divided into three separate parts—viz., base, pedicel, and globe or head. On the exterior surface of the base there are three distinct areas or sets of sense organs, which severally have an anterior, posterior, and lateral aspect. These have long been considered to be special sense organs. The lower area is somewhat rounded on the face, and covered with delicate elevations of the epidermis, which take the form of circular papillæ. They are divided into rows, and between each row there is a line of curved hairs. Lowne states that there are two distinct sets of these lower organs, and Theobald, in his new work on *British Flies*, has repeated this statement; but in no instance have I met with more than one, and it has invariably a lateral aspect. The two upper organs are placed on opposite sides of the haltere—one anterior and the other posterior. They are much longer and larger than the lower one, but are like it in having rows of ridges beset with papillæ, separated by fine hairs.

Several sections show the lining epithelium remarkably well. In this place it is specially modified to form a sensory or nerve epithelium. The pointed ends of the cells are seen penetrating the papillæ of the lateral organ. The halteres receive their rich supply of nerves direct from the second thoracic ganglion. This

pair of nerves is the largest in the thorax and crosses to the opposite sides immediately on entering the ganglia. The pedicel is a hollow tube connecting the base of haltere with the globe. On the external surface it is covered with hairs; the interior is divided by a septum, which is continued the whole length of the pedicel; a large tracheal vessel passes through it to the globe, where it breaks up into many branches, which ramify in the tissue. I have not been able to trace any more in it.

Sarcophaga carnaria, longitudinal sections of haltere.—These show the vascular tissue in the so-called globe of the haltere (see Fig. 5). In all the halteres I have examined the deep invagination seen in these sections of the globe is invariably present, and there is always a mass of connective tissue extending from the invaginated wall to the opposite wall of the globe. The purpose of the invagination I do not know, unless by some means it allows of a certain amount of expansion and contraction of the globe. The large glands most probably secrete a fluid necessary for organs at the base of the haltere.

The halteres of diptera doubtless assist in their locomotion, but the evidence of their elaborate structure proves that they have another most important function. The position of the papillæ is such as to present a front in every direction, and their structure is so delicate as to permit vibration when sound-waves or other movements of the air impinge upon them. The nerve epithelium, bathed in fluid which is secreted in the globe, together with the very rich nerve-supply, also point to their being rudimentary auditory organs. Otoliths, so commonly found in the Crustacea and Mollusca, I have not met with here, but it is no proof that they do not exist.

The great number of papillæ (four hundred to five hundred) in each haltere, and the small number of olfactory organs (two in each antennæ) found in many flies which feed on the nectar of flowers, compared with *M. vomitoria* and *M. domestica*, whose halteres carry half the number of papillæ, and in whom the olfactory sense is highly developed, show that the former possess an acute sense to warn them of danger when their heads are buried in the blossoms of the plants they frequent, and that the latter have comparatively little use for such a sense.

Blow-fly, Anterior thoracic spiracle of.—This spiracle is oval and narrowest above, and is situated between the pro- and meso-thorax. From the exterior free edge project hollow, arborescent, chitinous rods which curve outwards, and interlock for about one-third of the length of the spiracle. These rods are hollow even to the minutest twigs, and have free openings at their points; close behind is a transparent membrane, the true valve, which is united to the wall of the large tracheal vessel, which extends across the thorax to the opposite spiracle. The free edge of the valve is closely set with a chitinous fringe. A special muscle arises from the integument at the lower end of the spiracle; by the contraction of the muscle the free edges of the valve would be caused to approach each other. From the integument another set of muscles arise and are directed towards the valve, but whether they are connected with it I have not been able to determine; antagonistic muscles are a necessary consequence for working the valve.

The structure of the posterior thoracic spiracle is very similar to the anterior one, excepting that the external chitinous rods are formed into two distinct masses by the addition of a connecting membrane.

Sericomyia borealis, Posterior thoracic spiracle of.—This spiracle differs from the corresponding one of the Blow-fly in having the chitinous rods free, and also that the walls behind the valve are lined with walls of membrane, the edges of which are directed inwards.

Abdominal Spiracle of Blow-fly.—The spiracles of the abdomen are very much smaller than those of the thorax, their relative sizes being as 1 to 7. The spiracle is round, fringed with fine hairs, and the valve, which is placed a very short distance behind it, appears to consist of a thickened membrane on the one side which gradually thins out towards the free edge. The other half is thinner and more flexible, and its movement is effected by a curved rod or bow, hinged at one end, the other being connected with a set of muscles arising from the edge of the spiracle. No antagonistic muscles have been found by me, but if air is both received and expelled by it, such muscles are certainly requisite.

It is the generally accepted theory that all the spiracles are

both afferent and efferent; but, judging from the observations of others, as well as my own, I must confess that I am somewhat sceptical on the subject, and it is with the hope of having the matter thoroughly discussed that I have placed the slide in the box.

The minuteness of the opening of the abdominal spiracles and the almost immediate branching of the large tracheal vessels are eminently suited for the exclusion of dust particles; and the quick distribution of inflowing air, to which may be added the adaptability of the abdomen for rhythmical expansion and contraction, leaves no doubt that the supply is obtained through these spiracles. To be able only to assert that the tracheæ branch and re-branch until they end in mere blind twigs, and that the air is constantly being changed in them, without being able to discover the cause, is, to say the least, unsatisfactory.

By mounting fresh insect muscle in strong glycerine, I have succeeded for a time in retaining air in the smallest tracheal vessels, and believe that I have traced a connection through them to and from the larger tracheæ. My difficulty in following them was so great and perhaps uncertain that I should be glad to have my conjectures confirmed by more able observers before it can safely be stated as a fact.

On the other hand, the thoracic spiracles in the Blow-fly and in many other insects are large and open outwards, so that there is little or no protection against the entrance of dust particles; the various parts also of the thorax are so firmly soldered together as to make it almost rigid. These spiracles appear to me to be purposely and peculiarly adapted for carrying off the expired air and vapour from the body.

There is yet another purpose which these spiracles may probably serve—namely, the production of sound. The well-known buzzing of the fly can be varied in tone or may cease altogether, as circumstances require. Is it not conceivable that by varying the size of the opening of the valve of these spiracles, and thereby increasing or diminishing the pressure in the large air-tubes connected with them, such variations of sound may be accounted for? When the wings and halteres of the fly are removed ,the sounds produced are as loud as before removal, and the muscular exertion is always great when sounds are produced.

I desire to express my great pleasure in the examination of Mr. Jenkinson's beautifully mounted slides, and in the perusal of his interesting and instructive notes, as well as my satisfaction in seeing the work of so earnest and careful a worker circulating among our members.

Hairs on the Pulvilli of Flies.—With regard to the difficulty respecting the hairs on the pulvilli of flies, is it to be expected that the hairs should be hollow, and in the nature of ducts for the viscid fluid secreted by the glands? Do they—the hairs—not act rather as a simple mechanical method for enabling the insect instantaneously to detach its foothold from the object upon which it has been resting? and supposing the pulvillus to be hairless, and the secreting surface to be brought into close connection with the object, would there not be great difficulty in the creature at once liberating itself?

Frontal Sac.—The function of the frontal sac is a very interesting subject, and I am inclined to agree with Mr. Jenkinson that it acts largely as a compensatory arrangement in the adjustment of the pressure upon the organs of the head, in which the protrusion of the proboscis and its retraction must otherwise occasion considerable variation, but at the same time it doubtless fulfils other purposes.

I have not yet seen Prof. Lownes' new edition of his work on the Blow-fly, in which, however, I believe he has in several ways considerably modified his views on certain points communicated in his first edition; and do not know whether the views he held upon the frontal sac are in any way altered, but I think he there ascribed several functions thereto. The first of these was that this sac effected the purpose of a lever to enable the maturing imago to escape from the pupal case by forcing off the upper end and so permitting the insect to escape. At this time the frontal sac, which forms a cavity *in* the head of the mature fly, is everted, and forms a protuberance in front of the head, which, however, immediately after convergence, collapses and is withdrawn into the head, from which, by a slight pressure, it can be again made for a short time only to protrude.

The second function is in connection with the humming of the

insect, as he says the facial plate is caused to vibrate rapidly during the emission of sound, which in the apparent absence of sufficient muscular power it is difficult to conceive.

The last is that it is an olfactory organ, though with a limited nerve supply, by means of which the creature is enabled to appreciate powerful odours. Mr. Jenkinson's last suggestion—viz., the function of the laterally opening tracheæ in the interior of the body by means of capillary vessels—or something analogous—it seems to me, will be very difficult to establish; and if so, the advantage of such connection would appear doubtful owing to the extreme minuteness of such capillaries did they exist, for any exchange of air in the tracheæ which is effected by the respiratory movements of the abdomen could hardly proceed more rapidly one way than the other. E. Bostock.

Hairs on the Pulvilli.—I quite agree with Mr. Bostock that the hairs beneath the pulvilli may act mechanically in helping to relieve the foot. My difficulty is simply this:—If the glands in the pulvillus secrete a viscid fluid, how is that fluid conveyed to the under-surface of the pulvillus? When I approached the subject, I expected to find a lumen in each hair, or, failing that, minute ducts passing through the external wall, but I can find neither.

The Frontal Sac is continuous with, and is simply an invagination of the epidermis. It is a flexible bag, floating in and surrounded by fluid, and in my opinion is unsuitable for producing quick vibrations, but would rather tend to subdue them; hence, I think, we must look somewhere else for the "humming" organ. It is equally unsuitable for an olfactory organ, because its only nerve-supply could be obtained by its outer edges, and these would be very limited, even if they exist at all, which is extremely doubtful.

The experiment of placing the thorax of a cricket under water, while the abdomen had free access to the air, showed bubbles of air emitted from the thoracic spiracles, without the insect being in the least exhausted. When the *abdomen* was immersed no bubbles were emitted, and the insect suffered from exhaustion. Such experiments, coupled with the construction of the thoracic spiracles, suggest that they are outlets for the expired

air. Minute air-vessels do exist in very great numbers, both in the thorax and abdomen. W. JENKINSON.

I think we have never had any box that could beat this, and very few that could come up to it. If there are any members who (as Mr. Jenkinson thinks) can feel no interest in these slides—well, so much the worse for those members! If members generally would take half the trouble that Mr. J. has taken to please and instruct, and if they would (as Mr. J. has done) send out their best slides, then I think the prospects of the Society would rapidly improve.

Tarsus and Pulvilli.– I am not quite sure what is meant by "semi- or half- tubes"; the tubes seem to me to be separate. I do not see why the walls of the gland-cases should not be porous and the viscid fluid ooze through. I consider that the suggestion that the viscid fluid takes up and retains disease-germs for the benefit of man *wholly inadmissible.* I believe it to be an axiom in evolutionary science that no creature developes any organ or habit for the benefit of any other, unless it is itself benefited by benefiting the other, as in the case of the ants and the thorny acacia of South America.

The opinion of Mr. Newton as to the *Organ of Memory* in the head of the Blow-fly seems very daring and entirely unverifiable.

Frontal Sac.—I confess I do not understand the speculations on the function of the frontal sac. Is it meant that when the proboscis is protruded it is distended with air? I should have supposed from analogy it was more likely distended with blood.

With regard to Mr. Jenkinson's postscript, the experiment with the cricket seems to establish the theory of the efferent functions of the thoracic spiracles; but to make the proof complete it would be necessary to establish a connection between the tracheæ of the abdominal and of the thoracic spiracles; or might it be possible that the air introduced by the afferent tracheæ should be discharged into the cavity of the body, and taken up thence by the efferent tracheæ to be discharged through the thoracic spiracles?

R. S. PATTRICK.

Haltere of Sericomyia borealis.—An examination of the haltere above the spiracle on this slide, with a Zeiss' $\frac{1}{2}$-inch apochromatic, shows its head to be trumpet-shaped, not globular, the trumpet part being apparently continuous, with a long tube leading to the special sense-organs below. Of course, the head may have been globular and have become conical by shrinkage, but I do not think so. WM. GIFFORD.

EXPLANATION OF PLATE IX.

Fig. 1.—Section of Pulvillus of *Sarcophaga carnaria.* *p.w.*, Posterior wall; *s.t.*, Semi-tubes; *g.*, Glands; *h.*, Fine hairs.

,, 2.—One facette of Eye. *c.*, Cornea; *p.*, Pseudocone; *p.c.*, Pigment cell; *n.p.*, Nuclei of Pseudocone; *n.r.*, Nucleus of Retinula; *r.*, Retinula; *rh.*, Rhabdom; *t.v.*, Tracheal vesicle; *b.c.*, Basal pigment cell; *t.f.*, Terminal fibres.

,, 3.—Vertical Section through Head of Blow-Fly. *e.*, Compound eyes; *f.s.*, Frontal sac; *p.b.*, Base of Proboscis retracted.

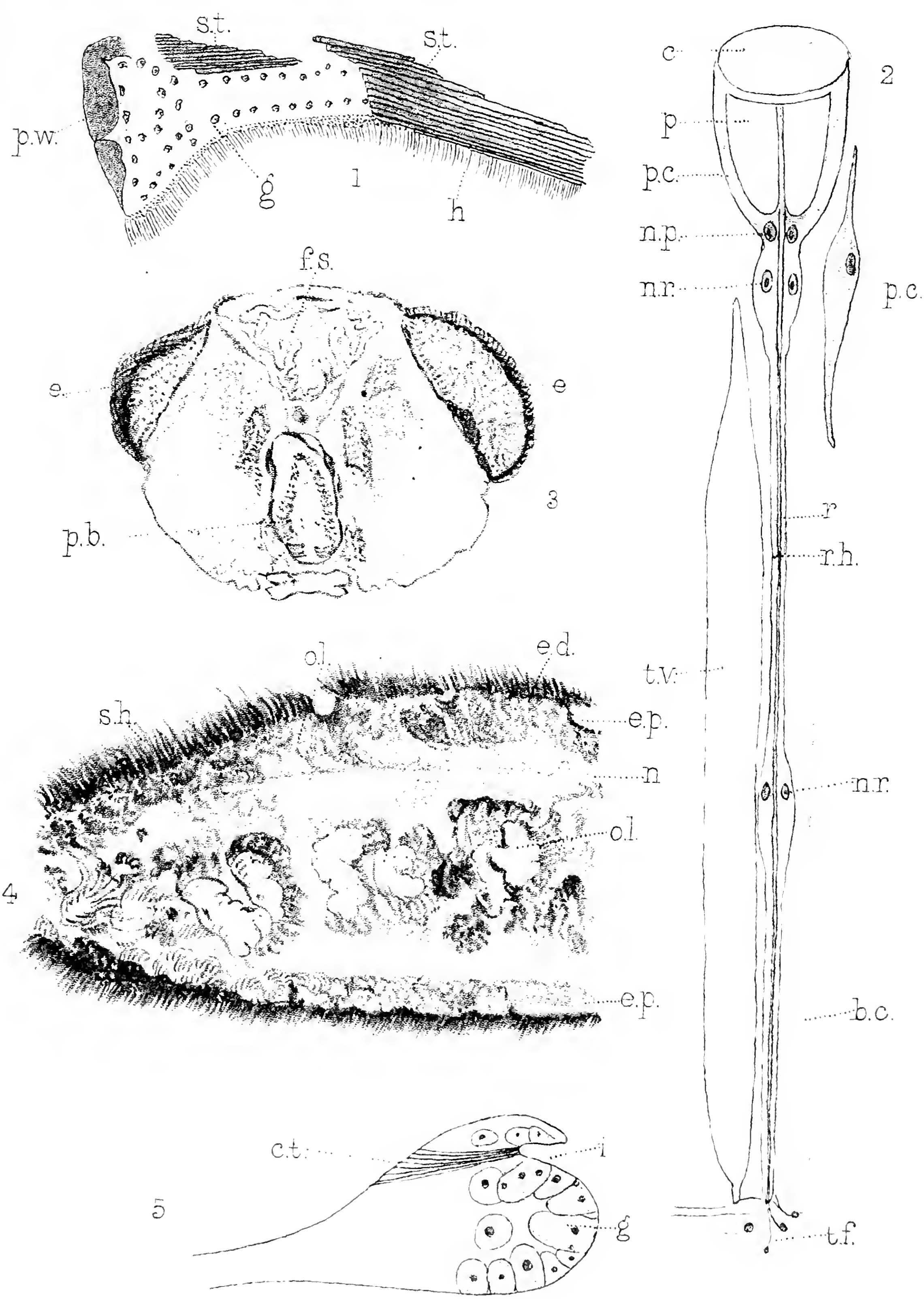
,, 4.—Longitudinal section of third joint of Antennæ of Blow-fly. *e.d.*, Epidermis; *ep.*, Epithelium; *n.*, Nerve; *s.h.*, Sensitive hairs; *ol.*, Olfactory organs.

,, 5.—Section of Globe of Haltere of *Sarcophaga carnaria.* *i.*, Invagination; *c.t.*, Connective Tissue; *g.*, Glands.

ADDITIONAL NOTES.

Peronospora infestans (Pl. XI.) (*Phytophthira* of De Bary) belongs to *Oosporeæ*, a group of THALLOPHYTES distinguished by their organs of reproduction—peculiar large cells called *oogonia* or resting spores. *P. infestans* is remarkable for possessing two modes of reproduction—first, a sexual one by oogonia and antheridia; second, an a-sexual one by gonidia or buds (compare *Marchantia polymorpha* among the Hepaticæ). The drawings on Plate XI. are partly copied from Sach's *Text-book of Botany*, which illustrates the life-history of this plant.

In July or August it is first observed forming yellow spots on the leaves of the potato, which then turn brown and wither. The underside alone of the leaves is at first affected, as the stomata there afford an easy mode of entrance to the germinating mycelia of the fungus. In Fig. 2, *Z*, this is seen. The mycelia put forth haustoria, Fig. 2, into the protoplasm of the cells to suck up the sap, and the withering of the plant is caused by the fungus



Anatomy of Diptera.

W. Jenkinson, ad nat. del.

F. Phillips, Sc.

thus exhausting the protoplasm of the cells. After the mycelia have obtained a lodgment and ramified through the intercellular spaces of the potato, branches are pushed out through the stomata on the underside of the potato leaves, and on the ends of these the gonidia are formed (Fig. 1, *g*). These branches are remarkable in form, resembling a string of beads. They, as well as the gonidia at their ends, are white, and give a hoary appearance to the diseased leaves.

The resting spores of this fungus were discovered by Mr. Worthington Smith. Those of a similar kind of fungus, *Cytopus candidus*, are copied from De Bary's figure in Fig. 6. Those seen in the slide are represented at Fig. 3. Two kinds of spores seem to be present—a few large, light-brown ones and a number of small, dark-coloured ones. I presume the latter are gonidia and the former oospores. Fig. 5 shows the mode of fecundation of the oospores in *Cytopus*.

I have a few leaves of the potato with the disease on them in my possession; on these I notice some small, round, rose-coloured bodies which puzzle me. C. H. WADDELL.

As to the *resting spores* of the potato disease, they will be seen best by day-light illumination and a $\frac{1}{4}$-inch o.g. There are two schools:—First, those who believe that the mycelium lives all the winter in the tuber, grow up in the summer, and thrives as the plant thrives, and appears through the stomata. The second school is of those who hold that the harm is in the resting spore. This is the product of last year's disease, produced in exhausted seeds and intercellular structures, in decaying potatoes and plants, among manure, or in fields. It is produced by the union of protoplasms of two cells. An interesting article on this subject will be found in the *English Mechanic* of May, 1881. C. P. COOMBS.

Larva of Stratiomys chamæleon (Plate X.).—This is a dipterous larva, common enough at Sheerness, and I daresay in other parts of the country. It is a repulsive-looking object, that floats inertly on the surface of the water in ditches and ponds. One might easily think it inanimate, but a touch with a stick causes it to twist and writhe for a moment; it then relapses into a quiescent condition. This creature is roughly portrayed in Pl. X., Fig. 1. It is the larva of a handsome fly, *Stratiomys Chamæleon*. There

are many points of interest about it, only a few of which I can here touch upon. It might easily be a subject of wonder how so helpless a creature, whose habitat renders it so peculiarly liable to observation and attack, could survive the assaults of its numerous enemies; and the answer is doubtless to be found in the structure of its skin, as shown in Figs. 2 and 3. This skin is extremely tough, and yet flexible to allow the freest motion to every segment of the body. It is a veritable coat-of-mail. Certain cells of the cuticle are developed into horny studs which beset the surface, and form a complete protective covering, the substratum upon which they are placed being soft and flexible.

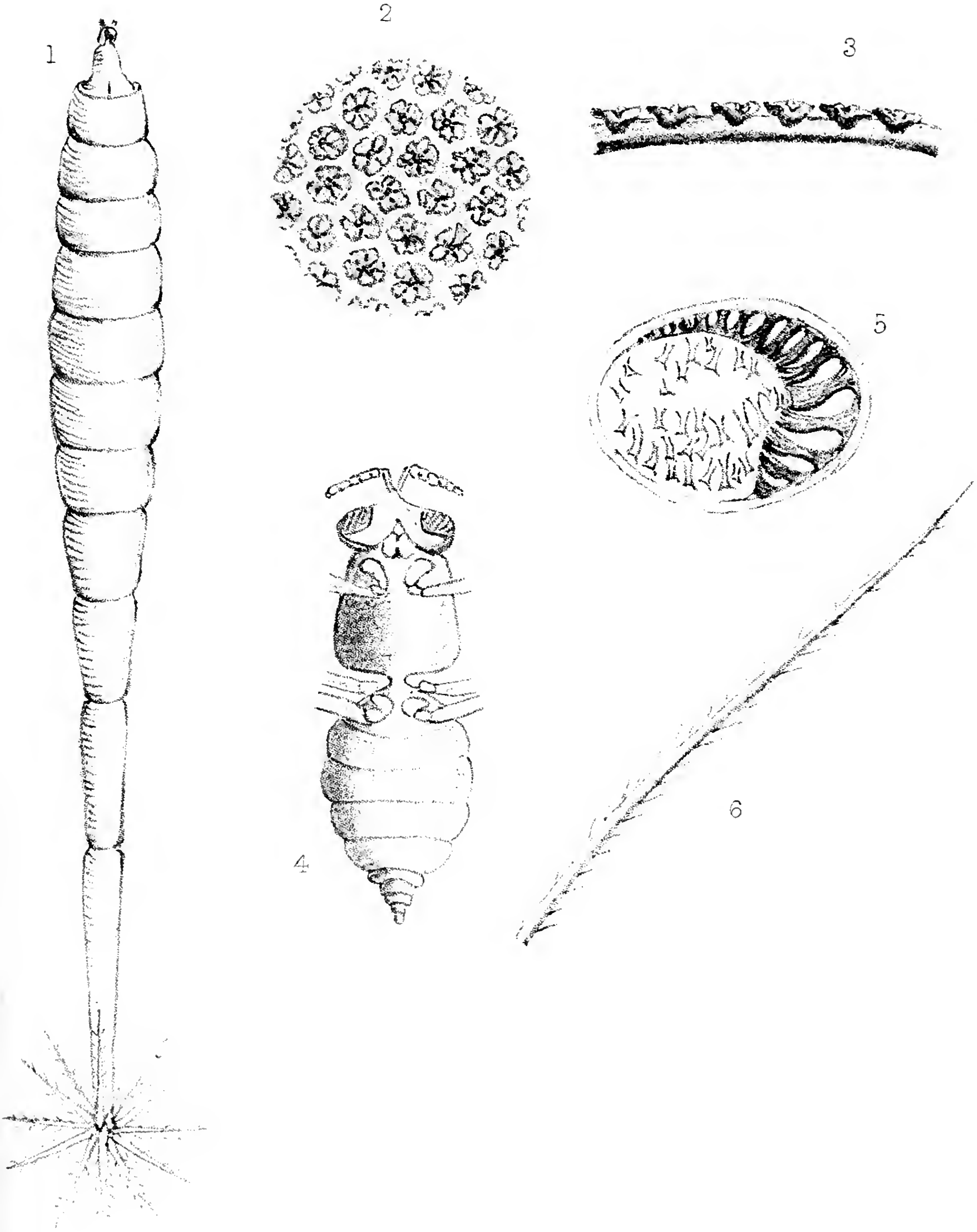
The tail exhibits a coronet of branching hairs, one of which is seen in Fig. 6, and these surround a couple of peculiar oval spiracles, one of which is shown in Fig. 5. I have not a very good drawing of the Fly itself, but Fig. 4 will give some idea of it. The pupa is developed within the skin of the larva, of which it occupies only the anterior portion. A. HAMMOND.

Ditto.—Those who possess Donovan's *British Insects* will find at p. 65, Pl. XXXI., a coloured figure of the fly under the name of *Musca Chameleon*, and at p. 77, Pl. XXXV., a figure of the larva. Mr. Hammond's further figure, showing the peculiar structure of the skin, is very welcome and interesting, and well proves that good objects for the microscope, as well beautiful as interesting, abound everywhere, and only require looking for. The present creature appears to have had its name changed, at least, four times. This is rather a difficulty in the way of the beginner. Donovan says that in a former edition of his fauna, Linnæus calls it *Œstrus aquæ*, Frisch *Tabanus aquaticus;* in the last edition of *Fauna Suecia*, *Musca Chameleon;* and now it has become *Stratiomys Chamæleon*, let us hope it has now acquired its final name, at least for this century. C. F. GEORGE.

EXPLANATION OF PLATES X. & XI.

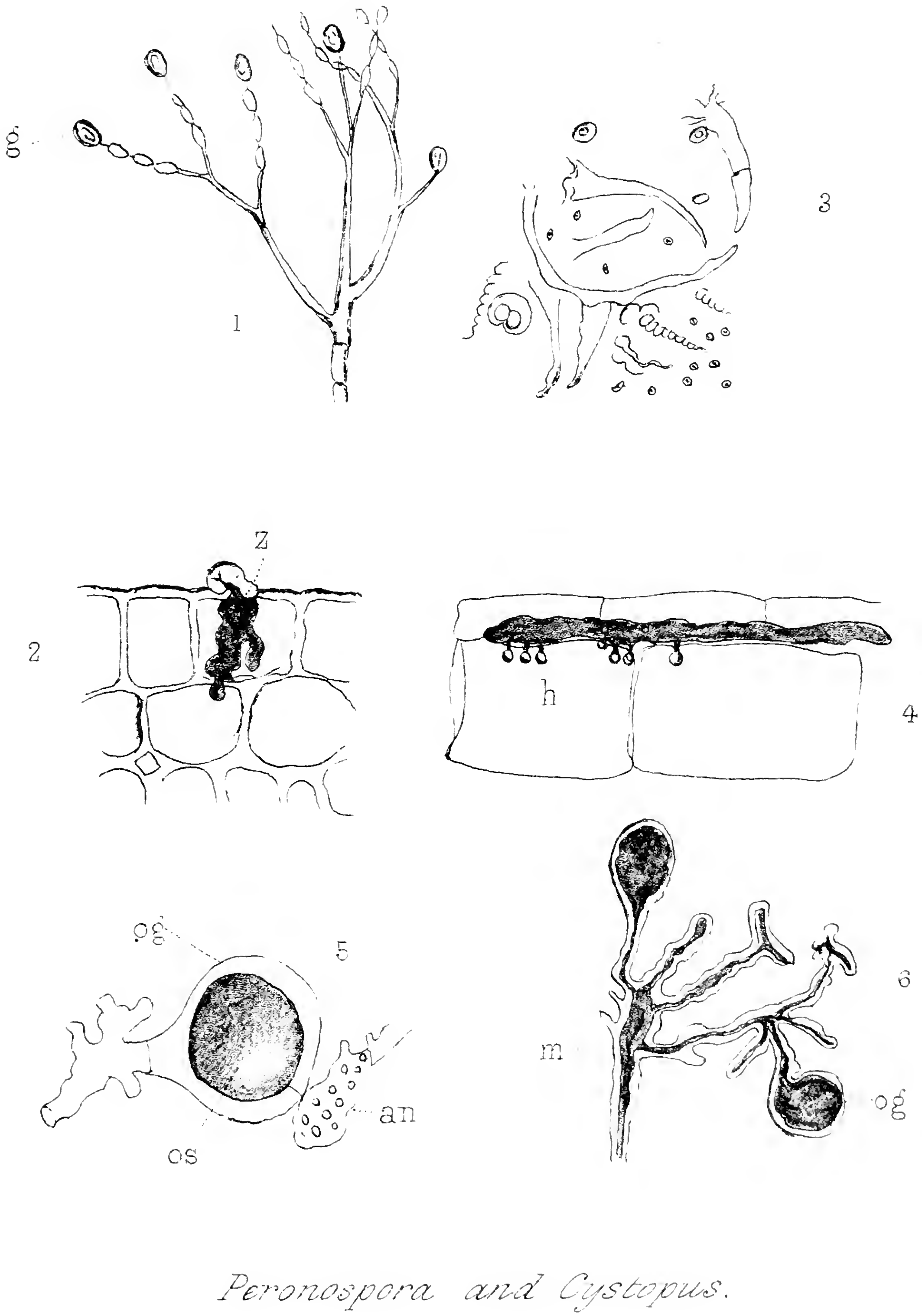
PLATE X.

Fig. 1.—Larva of *Stratiomys chamæleon.*
,, 2.—Portion of skin of same.
,, 3.—Section of ditto.



Stratiomys Chameleon.

A Hammond F.L.S. ad nat. del. F Phillips Sc



Peronospora and Cystopus.

C. H. Waddell.

F. Phillips Sc.

Fig. 4.—Ventral surface of imago.
,, 5.—Spiracle.
,, 6.—Hair from Coronet.

PLATE XI.

Fig. 1.—*Peronospora infestans.* *g.*, Gonidia *in situ* on ends of mycelia projecting from stoma of leaf. (After Cooke.)
,, 2.—*z.*, Zoogonidia penetrating epidermis of Potato stem (after De Bary).
,, 3.—Spores of *Peronospora infestans*, as seen on slide.
,, 4.—*Cytopus candidus.* Branch of Mycelium with haustoria (*h.*), penetrating between parenchymatous cells.
,, 5.—*o.g.*, Oogonium ; *os.*, Oosphere ; *an.*, Antheridium in *Cytopus candidus* (after De Bary).
,, 6.—Mycelium (*m.*) with young oogonium (*o.g.*).

Microscopical Technique.

Preparation of Frozen Sections by means of Methyl and Ethyl Chloride.*—In September, 1895, while watching Dr. John B. Deaver perform a minor surgical operation with ethyl chloride, the thought occurred to me that this re-agent might profitably be employed in preparing frozen sections for histological purposes. The results thus far obtained have been exceedingly satisfactory, and, while the method is somewhat expensive, no accessory apparatus is required for the microtome.

Hamilton's method of preparing the tissues for freezing gives good results (*Text-Book Pathology*, by D. J. Hamilton, Vol. I., p. 58). Another way of getting the tissue ready is that recently advised by J. Orth (*Berlin klin. Woch.*, No. 13, 1896). One hundred parts of Müller's fluid are mixed when wanted with ten parts of formol. Small pieces of the tissue under examination are fixed and hardened in this solution in the incubator for three hours. At the end of this time they are removed and thoroughly washed, and alcohol is gradually added until they are placed in 95 per cent. alcohol. This latter re-agent must, of course, be removed before the tissue is frozen. If desired, after washing, the specimen may be at once transferred to the solution of acacia and sugar and

*From *International Medical Magazine*, Dec., 1896, pp. 706—7.

frozen. Or, as suggested by H. Plenge (*Virchow's Archiv.*, Vol. CXLIV., p. 409), the piece may be placed in a 4 per cent. formaldehyde solution for a quarter-of-an-hour, and then frozen in the same solution.

When the tissue has been prepared in some such manner, or even when perfectly fresh, it is placed with some formol and gum acacia fluid upon the specimen-holder of the microtome, and a small stream of chloride, methyl chloride, or anestile (a mixture of these two re-agents) is played from above directly upon the specimen. The tube containing the ethyl chloride is held about a foot from the specimen, and moved from place to place until the specimen is firmly attached to its base of support, and the upper portion is coated with a few crystals of ice. These crystals are extremely small and delicate, and, therefore, do not injure the tissue so markedly as in some other of the freezing methods. The specimen is readily frozen in from thirty seconds to a minute. Sections are then cut and placed in water or fifty per cent. alcohol, and mounted in the usual way. Excellent stained preparations may be prepared in fifteen minutes or less from the time that the tissue is removed from the body.

We hope to give a later and fuller report of this process at an early date. H. W. CATTELL.

Formaldehyde in Pathological Work.—Orth (*Berl. klin. Woch.*, March 30th, 1896) draws attention to the value of this agent in pathological work. Formol, or formalin, contains 40 per cent. formaldehyde. It is generally known that formol is an excellent hardening agent for most tissues, and especially for the brain, as well as for red blood-cells, which it preserves and fixes. Both for naked-eye and microscopic purposes the author has employed a 10 per cent. formal in Müller's fluid. After two or three days this solution becomes dark, and in four days a crystalline deposit separates out. Thus the fluid requires changing in this time, but mostly the hardening process is already completed. Small pieces of tissue, measuring ⅓ to ½ cm. in thickness, are thoroughly fixed and hardened in three hours in a warm chamber. Larger pieces may remain overnight, and this time suffices for small pieces at room temperature. The Müller is washed out with water. The

specimens after washing can be put in 93 per cent. alcohol, and if the washing has only taken a short time they may be left in it from twelve to twenty-four hours. Remaining in the fluid for three or four days at room temperature does not injure the specimens, but rather facilitates the subsequent staining. Karyokinensis may thus be more frequently observed. Carmine preparations, also hæmatoxylin and methylene blue, are efficient staining re-agents

The hardening in formol-Müller is especially suitable for bone decalcified with phloroglucen and nitric acid. For naked-eye specimens formol-Müller is also useful. Besides blood, fat, cartilage, and bone are thus well differentiated, and pigments, colloid material, etc., are also well fixed. Hæmorrhagic nephritis, fatty degeneration of the heart, etc., are well prepared by this method. The colouring of the grey and white matter of the brain is very satisfactory. Weaker alcohol (60 per cent.), to which formol (1 per cent.) has been added, is a good preservative fluid after formol-Müller; also a combination of alcohol, glycerine, water, and formol (1 per cent.) may be employed. Embedding in gelatine, to which 1 per cent. formol has been added, is successful. For the preservation of tissues for demonstration 1 per cent. formol is very useful. The specimens may be dipped in this solution, and then wrapped in cloths soaked in it. Formol is very valuable as a disinfectant, particularly for washing the hands after a *post-mortem* examination. The vapour is irritating, and therefore people should not remain in a room where it is present for only a short time.—*Brit. Med. Journal.*

Growth of Diatoms.—Mr. G. C. Whipple has carried on a series of experiments on the culture of different kinds of diatoms, and finds that an abundant food-supply is not the only condition favourable for their rapid increase; the temperatnre, the amount of light, and other factors influencing their growth. In common with all other chlorophyllaceous plants, diatoms will not grow in the dark, while, on the other hand, bright sunlight also kills them. The intensity of the light below the surface of the water being affected by the colour of the water, diatoms are found most abundantly in light-coloured water. Different genera, however, exhibit differences in this respect. *Melosira* does not require so much light as *Synedra.* The weather has a marked influence on the

growth of diatoms. They increase most rapidly during those seasons of the year when the water is in circulation throughout the vertical currents. During these periods not only is food most abundant, but the vertical currents keep the diatoms near the surface, where there is light enough to stimulate their growth, and where there is abundance of air. Some species display strong heliotropism, moving towards the source of light.—*Pharm. Journ.*

A New Method of Staining Nervous Tissue.—Vastarini-Cersi (*Rif. Med.*, Feb. 14, 1896) describes a new and effectual method of staining the spinal cord, etc., for macroscopic purposes. The entire cerebro-spinal axis, with the meninges, is plunged into about 3 litres of an aqueous solution of formaldehyde (16 per 1000). The tissue is left in the medium for two weeks, the meninges being removed on the second or third day. Sections from 3 to 5 cm. thick are then cut and kept in distilled water, or, better, in alcohol at 40°, for twelve or twenty-four hours; then plunged into 75° solution of AqNO3 in the dark. The white substance soon becomes stained brown. A prolonged stay in the Aq NO3 sol. does no harm. The stain may be fixed for an indefinite time if the preparation is left for two or three days in the dark in distilled water and then in alcohol at 70°. Tissue so prepared shows in the clearest manner the relations between the white and the grey substance. For example, in the medulla one could distinctly see with the naked eye the respiratory fascicules of Krause. The advantages claimed by the author for this method are its simplicity and rapidity of execution, the constancy of the results, and its great teaching value.—*Brit. Med. Journ.*

Differentiation of the B. coli from the B. typhi abdominalis.—Elsner (*Zeitsch. f. Hyg.*, XXI.) uses plates prepared with Holtz's potato gelatine, to which, after it has been made slightly acid, 1 per cent. of iodide of potash has been added. Even on this unfavourable medium the *B. coli* grows freely and quickly, but no colonies of the *B. typhi abd.* are visible for forty-eight hours, and they appear as extremely fine, small, shining patches, like drops of water. Controlling his experiments by Pfeiffer's immune-serum process, Elsner always obtained positive results from typhoid stools. Piorkowski, at the Berlin Medical Society (June 10, 1896), reported

experiments in cultivating these bacilli on agar, bouillon, and gelatine mixed with urine, which had been suggested to him by the presence of *B. coli* in the bladder. On these media the microbe grew luxuriantly, forming greyish colonies; the *B. typhi abd.* less rapidly in fine transparent patches. In the discussion Elsner said there were plenty of differential signs; the difficulty was to cultivate Eberth's bacillus when it was only present in small number—for instance, in water, or mixed with other bacteria, for example, in stools. Ewald, Wolf, and Senator, all had found Elsner's method very useful for the diagnosis of doubtful cases from the stools.—*Brit. Med. Journ.*

Notes.

HELIUM.—From the results of the experiments recorded in this paper, it seems that helium exists in the minerals in which it is found in a condition comparable with that in which hydrogen is associated with many metals, and carbonic oxide especially with iron. Whether this condition is rightly distinguished from ordinary chemical combination is a question which admits of debate. The stability of all dissociable compounds is influenced by pressure and by temperature in the same kind of way as "occlusion," which, like ordinary chemical combination again, is a phenomenon in which the bodies concerned exercise a power of selection.

The presence of hydrogen as well as carbon dioxide in granite, if already observed, is not known to geologists generally. From observation on variations in the critical point of carbon dioxide in minerals (*Journ. Chem. Soc.*, 1876, II., 248), Hartley seems to infer that the incondensable gas present with carbon dioxide is usually nitrogen. A passage in Geikie's *Text-Book of Geology*, 3rd edit., p. 110, refers to the presence of hydrogen in cavities; but no information is given as to the evidence upon which this statement is based. The presence of hydrogen in such a rock as granite must be attributed to the existence of this gas in large proportion in the atmosphere in which the rock was crystallised. Whether this was the primeval atmosphere of the earth before the hydrogen had escaped or had been oxidised into water, or whether it resulted

from the local action of water upon unoxidised metals or other materials in the interior of the earth, is a question which may be of some interest to the geologist. If the former hypothesis were adopted, it would perhaps be difficult to explain the absence of helium from the gas included in the rock; and, on the whole, the latter view appears to afford the more probable explanation.

Experiments show that hydrogen is present in even larger proportion in the granite from the neighbourhood of Dublin, and it is proposed to examine some other examples of the ancient crystalline rocks in order to determine the nature of the gases enclosed in them.

* * *

THE WILD NETTLE is known to contain a remarkable number of useful qualities. The leaf is an edible, and the liquid to be obtained from the stalk makes an excellent beverage. The fibre of the stalk may, under treatment, produce an excellent silk. For ages the plant has been used for this purpose in China, where it grows to a height of seven or eight feet. Only recently, however, has the machinery necessary to make the manufacture of this silk a profitable industry been produced. A machine called the decorticator has been invented, by means of which the fibre is stripped off in enormous quantities at a terrific speed. Ramie is the eastern name of the plant.—*The Counsellor.*

* * *

THE ORANGE GROVES OF NAPLES are planted with wild trees, which are grafted in the usual way and grow with bare trunks to four or five feet from the ground. The branches then run out and form the fruit-bearing portion of the tree. An ingenious and beautiful innovation has been introduced in one grove, and is described by Consul Neville-Rolfe in his latest report. Lemons are grafted upon the bare and non-productive stems of the orange, about two feet from the ground, and trained in garlands from tree to tree, thus not only increasing the productiveness of the grove very materially, but adding greatly to the picturesqueness of its appearance. Orange trees being usually planted in rows at a measured distance apart, a grove has usually a geometrical appearance, which is unsatisfactory, but this appearance is very much modified by the lemons, which break the lines in all directions. There is a legend, which most people firmly believe, that the

grafting of a second fruit on the parent stem materially alters the type and quality, not only of the original fruit, but also of the graft, and it is sometimes gravely asserted that "blood oranges" are obtained by grafting the pomegranate on to the orange. This, says the consul, is a complete fallacy. Both fruits retain their original quality, and neither borrows anything from the other. There is thus no difference between the lemons grown in the orange grove from those grown in the grove where lemons alone are cultivated.—*Pharmaceutical Journal.*

* * *

Prehistoric Human Teeth.—At a meeting of the Students' Society of the National Dental Hospital, held October 9th, 1896, Mr. Loftus H. Canton showed some interesting teeth which were found in a cave at Seturitz, Basses Pyrénées. These teeth, supposed to be those of the Cave Bear, were found in a bed of guano, which was in some places thirty feet deep. Along with them were large quantities of animal remains, and one curious feature was that five specimens of human teeth were found in the same place, together with human remains. Whether the human remains were contemporary with those of the animals, Mr. Canton could not say. The deep bed of guano was covered by a layer of stalagmite, varying between one to five inches in thickness, and above this another layer of guano was found, but not so deep as the lower layer. Finally, at the top of all was another layer of stalagmite. The fact of the remains being at such a great depth seemed to imply that they were of great antiquity.—*Journ. British Dental Association.*

* * *

Preservation of Flowers.—The following is a very old method of keeping flowers without loss of colour:—Dry some very fine, pure siliceous sand in the sun or oven; then take a wooden, tin-plate, or pasteboard box sufficiently large and deep, and place your flowers inside erect; then fill the box with sand until the last is about an inch above the top of the flowers. The sand must be run in gently so as not to break the flowers. Cover the box with paper or perforated cardboard and place it in the sunlight, oven, or stove; continuous heat gives the best results. After two or three days the flowers will be very dry, but they will have lost none of their natural brilliancy.—*Journal of Horticulture.*

Reviews.

A Manual and Dictionary of Flowering Plants and Ferns. In Two Vols. By J. C. Willis, M.A. Crown 8vo, pp. xiv.—224; xiii.—429. (Cambridge: The University Press. 1897.) Price 10/6.

The aim of the author has been to prepare a book to supply, within a reasonable compass, a summary of useful and scientific information about the plants met with in a botanic garden, or museum, or in the field. He gives such information as is required by any but specialists upon all plants usually met with, and upon all those points—morphology, classification, natural history, economic botany, etc.—which do not require the use of a microscope.

Vol. I. describes the Outlines of the Morphology, Natural History, Classification, Geographical Distribution, and Economic Uses of the Phanerogams and Ferns; and Vol. II. gives the Classes, Cohorts, Orders, and Chief Genera of Phanerogams and Ferns alphabetically arranged under their Latin names.

The Botanist's Pocket-Book. By W. R. Hayward. 7th edition, 12mo, pp. xxxvi.—226. (London: G. Bell and Son. 1892.)

This very useful little book contains in a tabulated form the Chief Characteristics of British Plants, with the botanical name, common name, soil or situation, colour, growth, and time of flowering of every plant arranged under its own order. There is also a good index, in which reference is given to the volume and page of Sowerby's Botany, in which a much fuller description of the plant will be found.

The Elements of Botany. By Francis Darwin, M.A., M.B., F.R.S., etc. etc. Cr. 8vo, pp. xvi.—235. (Cambridge and London: The University Press. 1896.) Price 4/6.

The fourteen chapters constituting this volume of the Cambridge Natural Science Manuals give the substance of the Botanical Lectures delivered to the Cambridge medical students; whilst in an appendix is given the details of the Practical work which accompanies the lectures. In these lectures the Bean, Ranunculus, Silene, Chrysanthemum, etc., are used to illustrate floral structure; Caltha for the ovule; Helleborus for the leaf; and the Pear, Gooseberry, Sycamore, etc., for the fruit. In the same way Yeast and Spyrogyra are made use of to illustrate nutrition and the general structure of plant-cells; and Mucor, Spyrogyra, and Pteris illustrate reproduction. There are nearly 100 good illustrations.

Practical Physiology of Plants. By Francis Darwin, M.A., F.L.S., and the late E. Hamilton Acton, M.A. Second edition. Cr. 8vo, pp. xx.—340. (Cambridge and London: The University Press. 1895.) 4/6.

This is another of the Cambridge Natural Science Manuals, and consists of such a selection of experimental and analytical work as appears suitable for botanical students. Part I. deals with General Physiology in a somewhat elementary manner; Part II. treats a particular department of Physiology in a more special manner, and pre-supposes a greater amount of knowledge on the part of the student. There are 45 illustrations.

Maladies des Plantes Agricoles et des Arbres Fruiteres et Forestiers causées par des Parasites Végétaux. Par Ed. Prillieux. Vol. I., 8vo, pp. xvi.—421. (Paris: Libraire de Firmin-Didcot and Co. 1895.)

This work is the outcome of the author's twenty years' study and teaching of Economic Vegetable Pathology. He considers plant diseases to be due to changes of normal physiological functions produced either by unfavourable conditions or by the action of parasitic organisms penetrating the tissues. The

author first treats of Bacteria and Myxomycetes, then of the various Fungi—Phycomycetes, Ustilagineæ, Urudineæ, Basidiomycetes, and Ascomycetes. In the introduction the author gives directions for using the microscope, and distributed throughout the text there are 190 good illustrations. We are informed that the second volume will be published shortly.

PRACTICAL NOTES ON GRASSES and Grass-Growing in East Anglia. By William Spencer Everitt; edited by Nicholas Everitt. Cr. 8vo, pp. 154. (London: Jarrold and Sons. 1896.) Price 2/-

This book is written expressly for the Grass-grower, and contains many valuable hints as to the kinds of grass to sow and what kinds of seeds should be specially avoided. For those who do not know the various kinds of grasses by sight, illustrations would have been a great acquisition. As it is, it will doubtless prove of great assistance to the farmer.

LA PHOTOMICROGRAPHIE, Histologique et Bactériologique. Par J. Choquet. Royal 8vo, pp. vii.—149. (Paris: Chas. Mendel, 118 Rue d'Assas. 1897.)

In this fine work the author gives the results of many years' experience in the delineation of histological subjects by means of photography, and very carefully and fully describes the Cameras, Objectives, and Modes of Illumination suitable for this kind of work. A number of examples of Microphotography are given, besides 72 engravings in the text, showing the various apparatus. Without saying anything in disparagement of this work, we would suggest to the author that he might find a better form of condenser than the one he recommends on p. 64. The faint zone which he speaks of finding round the images given even by apochromatic lenses would entirely disappear by using from an achromatic substage condenser a cone of light of wider angle.

MICROSCOPIC RESEARCHES on the Formative Property of Glycogen. Part I., Physiological. By Charles Creighton, M.D. Royal 8vo, pp. viii.—152. (London: Adam and Charles Black. 1896.) Price 7/6 net.

Glycogen is that substance in the animal body which corresponds very closely with the starch of plants and its appearance in the cells of different tissues during development. The book is illustrated by five well-executed coloured plates. Chapter I. is an Historical Introduction; II. treats of Methods and Material—viz., Microscopic Method, method of using iodine, preservation of sections, colour of the iodide of animal starch, and reaction with methyl violet. The remaining eleven chapters treat of glycogen as found in various parts of the animal body.

MICROSCOPIC INTERNAL FLAWS inducing Fracture in Steel. By Thomas Andrews, F.R.S., F.C.S., M.Inst.C.E., etc. 8vo, pp. 52. (London: E. and F. N. Spon. 1896.)

A paper of considerable importance to Civil Engineers (reprinted from *Engineering*) on Microscopic Internal Flaws in Steel, Railway Locomotive and Straight Axles, Tyres, Rails, Steamship Propeller Shafts, and Propeller Crane Shafts, and other Shafts, Bridge Girder Plates, Ship Plates, and other Engineering Constructions of Steel. There are 30 micro. figures showing internal flaws.

PIONEERS OF EVOLUTION from Thrales to Huxley, with an intermediate chapter on the Causes of Arrest of the Movement. By Edward Clodd. Cr. 8vo, pp. xii.—250. (London: Grant Richards. 1897.)

The author here attempts to tell the story of the origin of the Evolution idea in Ionia, and, after long arrest, of the revival of that idea in modern times, when its profound and permanent influence on thought in all directions, and, therefore, on human relations and conduct is apparent. The book is divided

into four parts, and treats of—I.. Pioneers of Evolution from Thrales to Lucretius, B.C. 600—A.D. 50; II., The Arrest of Enquiry, A.D. 50—1600; III., The Renascence of Science, A.D. 1600 onwards; IV., Modern Evolutionists: 1, Darwin and Wallace; 2, Herbert Spencer; 3, Thomas Henry Huxley. A portrait of C. Darwin forms the frontispiece to the volume.

A Study of the Sky. By Herbert A. Howe, Professor of Astronomy, University of Denver (U.S.A.). 8vo, pp. 340. (London: Macmillan and Co. 1897.) Price 6/-

This is a thoroughly interesting book. The story is told with plainness and simplicity. The standpoint adopted is that of the astronomer, who observes, records what he sees, studies his observations, digs out the truths which they contain, and weaves them into laws and theories which embrace the visible universe, reaching from unknown depths of past ages up to unmeasured heights of futurity. An explanation of the apparent daily motion of the heavens is given and the chief constellations are set forth in detail. The book contains 144 good illustrations, many of them full-page.

The Natural History of Marketable Marine Fishes of the British Islands. By J. T. Cunningham, M.A.Oxon.; with a Preface by E. Ray Lancaster, M.A., LL.D., F.R.S. Royal 8vo, pp. xvi.—375. (London: Macmillan and Co. 1896.) Price 7/6.

Mr. Cunningham has for many years occupied the position of naturalist at the Plymouth laboratory, being specially charged by the Council with the investigation of the structure, habits, and breeding of marine food-fishes, and his book will undoubtedly serve as a help, not only to trained investigators, but to those who are able to give some portion of their leisure to this important subject. There are 159 illustrations and 2 coloured maps, one showing the fishing-grounds of the British Islands; the other the West Coast of Europe.

The Natural History of the Year for Young People. By J. Arthur Thomson. Cr. 8vo, pp. 288. (London: A. Melrose.) Price 3/6.

In this interesting little book the author tells us in plain words some of the great moves in the march of the seasons. The book is divided into four sections, one for each season of the year, beginning with Spring. Each of these is subdivided into five chapters. Most of them have appeared in the pages of *Young England*, but those of our young friends who read them there will do well to read them again; they cannot fail to interest and instruct. The book is nicely illustrated.

Object Lessons in Natural History. By Edward Snelgrove, B.A. Cr. 8vo, pp. 214. (London: Jarrold and Sons. 1897.) 3/6.

This capital little book is divided into 46 lessons; and provides a complete course in Elementary Science for the three Junior Standards of Elementary Schools, so far as Natural History is concerned. There is undoubtedly a decided advantage in placing together related subjects, so that threads of connection are clearly seen and firmly grasped, and this, we think, is fully carried out in the book before us. The illustrations, which are mostly in outline, will be found to convey their meaning very clearly, and we thoroughly approve of the style of reasoning adopted as being likely to convey to the mind of the child all that is required for it to know.

Footprints of the Lion and other Stories of Travel in Dalmatia, Montenegro, the Mediterranean, India, and Siam. By Major-General J. Blaksley. Second edition, enlarged. 8vo, pp. 115. (London: W. H. Allen and Co. 1897.)

This is a most interesting, handsomely got up, and beautifully illustrated

book. The first story ("Footprints of the Lion") is a description of a most delightful trip, which will most probably induce other English people to visit these interesting remains of what formerly was subject to the Queen of the Adriatic in her splendour. There are 33 full-page illustrations from photographs.

A HANDBOOK OF GAME-BIRDS. By W. R. Ogilvie-Grant. Vol. II. Cr. 8vo, pp. xv.—316. (London: W. H. Allen and Co. 1897.) 6/-

In this volume of Allen's *Naturalist's Library* the Pheasants is concluded. It contains also Megapodes, Curassons, Hoatzins, and Bustard Quails. This volume and Volume I. contain the names of every species of Game-Bird known up to the present date, so that they may be considered in the light of a small Monograph of the *Gallinæ*. There are 18 good coloured plates.

A HANDBOOK TO THE ORDER LEPIDOPTERA. By W. F. Kirby, F.L.S., F.Ent.S., etc. Vol. III. Cr. 8vo, pp. xxvii.—308. (London: W. H. Allen and Co. 1897.) Price 6/-

In this volume the Butterfly (Hesperiidæ) section is concluded, and is followed by twenty-six families of Moths, particular attention having been paid to species inhabiting the British Isles; whilst at the same time exotic species have been passed in review, illustrations of the principal families and of some of the most interesting genera of the exotic forms have been given. There are 37 well-executed and beautifully-coloured plates.

A DICTIONARY OF BIRDS. By Alfred Newton and Hans Gadon. Part IV. (Sheathbill—Zygodactyli), together with Index and Introduction. (London: A. and C. Black. 1896.) Price 7/6 net.

The part now before us completes this important volume, which was commenced in 1893. The entire work has been carried through in a most thorough and painstaking manner. It contains an exhaustive index of 30 three-column pages, and an Introduction of 124 pages, with an index. The work is well illustrated throughout.

THE STORY OF FOREST AND STREAM. By James Rodway, F.L.S. pp. 202.

THE STORY OF THE CHEMICAL ELEMENTS. By M. M. Pattison Muir, M.A. pp. 189.

THE STORY OF THE WEATHER, Simply told for General Readers. By George F. Chambers, F.R.A.S. pp. 232.

(London: Geo. Newnes, Ltd. 1897. Price 1/- each.)

It will be remembered that in an earlier volume of this series was published "The Story of the Plants," by Grant Allen. In the first of the vols. before us, the author gives some additional sketches on the life of the trees in wood, in forest; and as water is so necessary to their well-being, because without it there would be no forests, he has coupled the trees with the rivers. There are 26 good illustrations.

In the second of these little books the author gives in orderly sequence a few of the chief guiding conceptions of chemistry, avoiding as far as possible technical details, and illustrating these conceptions by describing many common facts.

"The Story of the Weather" is a subject in which all are more or less interested. It tells us many things about the weather, and presents in a handy form, and in unconventional style of language, a certain number of elementary facts, ideas, and suggestions which ordinary people, laying no claim to scientific attainments generally, are usually glad to know. It is nicely illustrated.

SCIENCE PROGRESS: A Quarterly Review of Current Scientific Investigation. New Series. Vol. I., No. 2. January, 1897. (London: The Scientific Press.) Price 3/-, or 10/6 per annum post free.

The January part of this Journal contains the following articles:—Liquid Crystals, by H. A. Miers, F.R.S.; Sugar—The Outlook in the Colonies, by C. A. Barber, M.A.; The Cell and some of its Constituent Structures, by J. Bretland Farmer, M.A.; Selection in Man, by John Beddoe, F.R.S.; The Glossopteris Flora, by A. C. Seward, M.A.; Condensation and Critical Phenomena, by J. P. Kuenen, Ph.D.; The Origin of Lakes, by J. E. Marr, F.R.S.; The Causes of Variation, by H. M. Vernon, M.A., M.B.; and in the Appendix, Notices of Books.

THE ZOOLOGIST: A Monthly Journal of Natural History. Fourth series. Vol. I., No. 1. (London: West, Newman, and Co.) 1/-

The fourth series of this well-known Journal commences under a new editor. It contains an editorial address, and papers on Recent Additions to the British Avifauna; On the Occurrence of the Pallas Willow Warbler in Norfolk; Man in Zoology; Notes from Norway; Notes on the Chacma Baboon; and Notes and Queries, etc.

A NEW ENGLISH DICTIONARY on Historical Principles, founded mainly on the Materials collected by the Philological Society. Edited by Dr. James A. H. Murray. DISOBST—DISTRUSTFUL. (Oxford and London: The Clarendon Press.) Price 2/6.

This section contains 1222 main words, 30 combinations explained under these, and 94 subordinate entries, making 1346 in all. Of the main words, 845 are current and native or fully naturalised, 365 (or about 30 per cent.) are marked as *obsolete*, and only 12 are marked as alien or not fully naturalised. In this part 1242 words are illustrated by 7316 quotations. It is indeed an exhaustive and masterly work.

BRYCE'S DIAMOND ENGLISH DICTIONARY. (Glasgow: David Bryce and Son. 1896.)

Messrs. Bryce and Son have favoured us with one of their curious little books. Its size is only $1\frac{3}{4}$ by $1\frac{1}{8}$ by $\frac{1}{2}$ in., and consists of 860 pages of very legible type, no magnifying glass being required. This dictionary comprises, besides the ordinary and newest words in the language, short explanations of a great number of scientific, philosophical, literary, and technical terms; it is nicely bound in leather and has gilt edges.

THE SWIFTOGRAPH INSTRUCTOR. Price 2/-

THE SWIFTOGRAPH READER. Price 1/- (London: Jarrold and Sons.)

These two books reached us at the moment of going to press. We shall, therefore, hold over any remarks on them until we have had more time in which thoroughly to examine the system. At present we confine ourselves to quoting the assertion of the author that it is "The Simplest System of Short-hand-writing in the World. *Learned in an hour.*"

INTRODUCTION TO THE STUDY OF CHEMISTRY. By W. H. Perkins, jun., Ph.D., F.R.S., and Bevan Lean, D.Sc., B.A. Lond. Cr. 8vo, pp. x.—339. (London: Macmillan and Co. 1896.)

The authors commence with a reference to alchemy and to some of the errors which were current until the 17th century, showing the readiness with which errors arose unless checked by well-devised experiment and careful measurement. Measurements are made of length, of mass, of the volume

of liquids, of temperature, of density, of pressure, and of heat. This is followed by the practice of important chemical operations, as solution, filtration, evaporation, etc. There are 136 illustrations in the text.

FIRST STAGE INORGANIC CHEMISTRY. By G. H. Bailey, D.Sc.Lond., Ph.D.Heidelberg; edited by W. Briggs, M.A., F.C.S., F.R.A.S., etc. Cr. 8vo, pp. viii.—210. (London: W. B. Clive.) Price 2/-

This book will be found to be a useful companion in the laboratory. The figures of apparatus are only given where some aid was thought to be necessary in their arrangement or fitting. In the earlier chapters instructions are given with respect to the methods to be employed by the chemist in conducting his enquiries. The entire work has been arranged to meet the requirements of the Science and Art Department for the Elementary stage, whilst some of the subjects have been more fully treated.

THE MEDICAL ANNUAL AND PRACTITIONER'S INDEX: A Work of Reference for Medical Practitioners. Cr. 8vo, pp. xxvi.—722. (Bristol: John Wright and Co. London: Simpkin, Marshall, and Co. 1897.) 7/6.

This important work, now in its fifteenth year, represents the united efforts of forty contributors residing on the Continent of Europe, in our Colonies, and the U.S. of America. Amongst other articles we notice a valuable paper on Leprosy by Dr. G. Armauer Hansen, of Norway; one on Oriental Diseases by Mr. Cantlie, who has lately returned from the East. The Dictionary of New Remedies and Review of Therapeutic Progress for 1896 occupies 90 pages; whilst the Dictionary of New Treatment in Medicine and Surgery covers more than 500. There are 27 plates, many of them coloured, and 113 wood engravings.

HERBAL SIMPLES approved for Modern Uses of Cure. By W. T. Fernie, M.D. Second edition. Cr. 8vo, pp. xxiii.—651. (Bristol: John Wright & Co. London: Simpkin, Marshall, & Co. 1897.) Price 6/-

From primitive times the term "Herbal Simple" has been applied to any homely curative remedy consisting of one ingredient only, and that of a vegetable nature. Many such a native medicine found favour and success with our single-minded forefathers. In this second and greatly enlarged edition much new matter has been added.

CHEMICAL RECIPES. By the Atlas Chemical Co., Sunderland. Third edition. Cr. 8vo, pp. xviii.—379. (Sunderland: Hills and Co., 19 Fawcett St. 1896.)

This book contains one thousand modern formulæ for producing all kinds of colours and other chemical compositions, with full explanatory notes and instructions for manufacture, etc. That the recipes herein given have been found useful may be judged from the fact that the first and second editions were entirely sold out within one year.

ADVANCED MECHANICS. Vol. II., STATICS. By William Briggs, M.A., F.C.S., F.R.A.S., and G. H. Bryan, Sc.D., F.R.S., etc. Cr. 8vo, pp. viii.—288. (London: W. B. Clive.) Price 3/6.

This volume of the "Organised Science Series" is the Tutorial Statics, together with the Questions of the last eleven years set at the advanced examination of the Science and Art Department. It includes those portions of Statics which are contained in the syllabus of the Science and Art Second (Advanced) Stage Examination in Theoretical Mechanics. The Principle of Work is freely employed throughout the book, and all the important bookwork is printed in larger type than the hints, explanations, examples, etc. At the

end of the book will be found all the Questions, both on Statics and Dynamics, that have been set in the Science and Art Second Stage Examination during the past eleven years.

BRUSH DRAWING, Adapted to Meet the Requirements of the Education Code, and the Alternative Drawing Syllabus of the Science and Art Department. By J. Vaughan. 4to. (London: Moffatt & Paige. 1896.) 3/-

This is one of the series of "Hand and Eye Training" books, which aim at developing three distinct and important faculties, viz.:—Dexterity of hand; appreciation of line, form, colour, and space; and accurate observation. There are 24 coloured plates of design, with full instructions and other descriptive letterpress.

THE TUTORIAL LATIN READER. Second edition. Cr. 8vo, pp. viii.—167 + 48. (London: W. B. Clive.) Price 2/6.

This contains a Graduated Series of Extracts for Practice in Translation at sight, with an Appendix of Passages set at the London University Matriculation and Intermediate Arts Examinations. The book is divided into Short Sentences; Short Sentences followed by the original passages from which the sentences have been formed; Prose Passages, so printed that each clause begins a new line; Easy Passages of prose and verse; and Harder Passages. The entire scheme of the book appears an admirable one.

AN ELEMENTARY TEXT-BOOK OF HYDROSTATICS. By William Briggs, M.A., LL.M., F.C.S., F.R.A.S., and G. H. Bryan, Sc.D., M.A., F.R.S. Second edition. Cr. 8vo, pp. viii.—208. (London: W. Clive.) 3/6.

The ground covered by this volume of the "University Tutorial Series" includes those portions of Hydrostatics and Pneumatics which are usually read by beginners and by candidates for examinations of a standard such as that of the London Matriculation.

SHAKESPEARE'S HISTORY OF THE LIFE AND DEATH OF KING JOHN. Fscap. 4to, pp. 190. (Cambridge: The University Correspondence College Press. 1895.) Price 2/-

The Introduction to this volume gives the History of the Play, the Sources of the Plot, and Critical Comments on the Play, and at the end are voluminous notes.

SELECTIONS FROM MALORY'S LE MORTE D'ARTHUR. Edited, with Introduction, Notes, and Glossary, by A. T. Martin, M.A., F.S.A. Cr. 8vo, pp. xxxvi.—254. (London: Macmillan and Co. 1896.)

Mr. Martin has given us here the Arthurian Legend in a concise and readable form. The student will find much to interest him in the Notes on Malory's Grammar. General Notes, Appendix on the Various Versions of the Legend of the Holy Grail, etc., are found towards the end of the book.

IS NATURAL SELECTION THE CREATOR OF SPECIES? By Duncan Graham. Cr. 8vo, pp. xviii.—303. (London: Digby, Long and Co.) 6/-

The author is evidently a man of very strong views and opinions; he maintains that the condition of the earth and its inhabitants cannot be explained by the action of physical forces independent of support and direction from an intelligent power. . . . Natural selection is a delusion; being only a *result*, and not an effective agency, it can produce nothing. The book is divided into 19 chapters, which we think will well repay careful reading.

THE ILLUSTRATED BIBLE TREASURY and Concordance. Edited by William Wright, D.D. 8vo, pp. xiv.—712. (London: T. Nelson and Sons. 1896.) Price 7/6.

The Bible in its original form is an Oriental book. Oriental men wrote it,

and employed the familiar objects around them as signs and symbols by which to make known God's purposes of mercy to men. . . . Our English Bible is a Western book, and to some extent draws a Western veil over the face of the Oriental book. It has been the aim of the publishers of this *Illustrated Teacher's Bible* to get behind the veil of Western words and ideas, and enable the reader to study the Book amid the surroundings and in the very atmosphere in which it was composed. There are upwards of 350 good illustrations, and an Indexed Bible Atlas.

THE OLD WORLD AND THE NEW FAITH. By W. Freeman Moulton, M.A. Edited by Rev. Arthur E. Gregory. 12mo, pp. x.—228. (London: Charles H. Kelly. 1896.) Price 2/6.

This little book consists mainly of Notes upon the Historical Narrative contained in the Acts of the Apostles. It is very plainly and concisely written and will repay careful reading. The frontispiece is a folding map, showing St. Paul's Journeys and the places mentioned in the Acts.

NEW THOUGHTS ON CURRENT SUBJECTS: Scientific, Social, Philosophical. By the Rev. J. A. Dewe. Cr. 8vo, pp. 230. (London: Eliot Stock. 1897.)

The author of the book before us is evidently a man who thinks deeply on many subjects. He says in the Preface:—"When we have a piece of bread before us, or any other material substance, we can see its colour, taste its flavour, and feel its weight; but the *it* itself—that is, the substance of the body—we cannot see; and it is my purpose to show how this mysterious *it* accounts for such phenomena as electricity and heat." The first section of the book—devoted to SCIENCE—treats of Sea-salts and Carbonates; The Nature of Heat and of Electricity; Stellar and Absolute Space; and the Science and Harmony of Smell. We pass over the SOCIAL section. Part 3—PHILOSOPHICAL—treats of Thought and Speech; The Nature of Music; Free-will *v.* Heredity and Environment; Spiritualistic Communications; and The Dogmatic and Scientific Accounts of the Creation of Man. The book is worthy careful study.

THE CLUE TO THE AGES. Part I., Creation by Principle. By Ernest Judson Page. 8vo, pp. 282. (London: Baptist Tract and Book Soc.)

The author, in his Preface, says:—"The reading of some recent works, in which the Evolutionary Hypothesis has been boldly and logically applied to the problems of the higher reaches of human life has led me to the absolute rejection of the Hypothesis as a sufficient explanation of the various facts and laws of development which it has been the singular glory of the passing generation to establish. . . In this work I have proposed an alternative theory, which seems to me a wider and truer generalization than that which, should it come to be accepted, it will supercede.

THE HIGHER CRITICISM: The Greatest Apostacy of the Age. By D. K. Paton. Crown 8vo, pp. 78. (London: Passmore and Alabaster. 1896.) Price 1/6.

The author divides this work into three parts:—I., The Falsity of the Position of the "Higher Critics." II.—The Worthless Character of the Work of "Higher Critics." III.—The Concluding General View and Condemnation of the "Higher Criticism."

HANDBOOK OF GOTHIC ARCHITECTURE: Ecclesiastical and Domestic, for Photographers and others. By Thomas Perkins, M.A. Cr. 8vo, pp. 224. (London: Hazell, Watson, and Viney. 1897.) Prce 3/6.

These articles, which, after careful revision, are reprinted from *The Amateur Photographer*, were written with a view of giving sufficient information to pho-

tographers to enable them to use their cameras intelligently in architectural work. Lovers of the beautiful in architecture will find much to interest them here, even if they are not interested in photography. The illustrations are exceedingly numerous and good.

THE CAMERA AND THE PEN. By J. C. Hepworth. pp. 64.

PHOTOGRAPHY AS A HOBBY. By Matthew Surface. pp. 61. (London: Percy Lund, Humphries, and Co. 6d. each.)

These very handy little books form Nos. 11 and 12 of the Popular Photographic Series. The first, among other articles, contains the following:—The Pioneer Process; Hints about Apparatus; Instantaneous Pictures; The Bleaching-Out; The Half-tone Process; Adding Tint to Line-Blocks, etc.

The other has an introductory chapter on Hobbies in General and one in Particular; Out with the Camera; Occupation at Home; and the Connection of Photography with other Hobbies. The size of these books, 7⅜ by 4 in., makes them very convenient for the pocket. Like all Messrs. Lund's works, they are well printed and well illustrated.

THE JUNIOR PHOTOGRAPHER. Conducted by Matthew Surface. Jan. and Feb., 1897. (London: Percy Lund and Co.) Price 3d.

The motto of the publishers, "Popular yet Practical, Elementary yet Progressive," is well carried out here.

THE PRACTICAL PHOTOGRAPHER: Devoted to the Art, Science, and Application of Photography. Jan., Feb., and March, 1897. (London: Percy Lund and Co.) Price 6d.

This is a handsomely got up and most useful publication.

THE AMERICAN ANNUAL OF PHOTOGRAPHY and Photographic Times Almanack, 1897. 8vo, pp. 370, (New York: The Scovell and Adams Co.) Price 2/-; stiff covers, 4/-, bound.

This is the eleventh volume of the Annual, and we cannot help thinking that each succeeding volume is better than its predecessor. There are 67 beautifully-executed full-sized plates and some hundreds of smaller illustrations in the text. The hints throughout the book will be found most useful.

A MANUAL OF PAINTING ON GLASS for the Magic Lantern. By P. Garnier. Cr. 8vo, pp. 62. (London: J. Barnard and Son.) Price 1/-

This gives instructions for Glass-Painting in Oil and Water-Colours for the Magic-Lantern, to which is added an account of the construction of lanterns, and how to use them.

A CASKET OF PHOTOGRAPHIC GEMS. By W. Inglis Rogers. Cr. 8vo, pp. xvi.—126. (London: Piper and Caster.) Price 1/-

This useful little book contains a collection of 500 Dodges, Receipts, Entertaining Experiments, etc., in connection with the art of Photography and its branches. These various dodges are intended to be used in the Field, the Dark-room, Printing-room, etc.

HOW TO CHOOSE A DOG and How to Select a Puppy; with Hints on the Peculiarities and Characteristics of each Breed. By Vero Shaw. Cr. 8vo, pp. xi.—82. (London: W. Thacker and Co. 1897.) Price 1/6.

The object of the author of this book has been to point out the uses and peculiarities in the dispositions of the different varieties of dogs; their respective properties; and to give an approximate idea of the weights of puppies at various periods of their existence.

THE ANIMAL WORLD: A Monthly Advocate of Humanity. Vol. 27, 1897. (London: S. W. Partridge and Co.)

This magazine is issued by the Royal Society for the Prevention of Cruelty to Animals. It consists of 192 large folio pages, and is full of most interesting reading matter and good illustrations. There are few young people who could not enjoy reading the *Animal World.*

THE BAND OF MERCY, Vol. 18. 4to, pp. 96. (London: S. W. Partridge and Co.)

This magazine is also issued by the Royal Society for the Prevention of Cruelty to Animals. It is handsomely got up, both inside and out. The reading matter is well adapted to children. Each monthly part contains a piece of bright music and the illustrations are well executed.

THE STORY OF VICTORIA, R.I., Wife, Mother, Queen. By W. J. Wintle. Cr. 8vo, pp. 143.

THE STORY OF ALBERT THE GOOD (Prince Consort). By W. J. Wintle. Cr. 8vo, pp. 143. (London: Sunday School Union.) 1/- each.

In the first of these we have an interestingly written sketch portrait, in which all that serves to illustrate the personal life and character of the Queen is included.

In the second the aim of the author has been to present a sketch of the personality of the Prince Consort. No statements of fact have been included except such as have received approval in the highest quarter. All quotations from letters, diaries, etc., have been inserted by special permission accorded to the author by Her Majesty the Queen. Both little books are nicely illustrated.

DAYBREAK: A Romance of an Old World. By Jas. Cowan; with drawings by Walter C. Greenough. Cr. 8vo, pp. viii.—399. (New York: Geo. H. Richmond and Co. 1896.)

The hero of this book visits the planet Mars, where he finds a much higher state of development than exists on the earth, or is likely to exist for many centuries yet to come. "Daybreak" is in reality a popular work on Sociology, it is written in a most interesting manner, and when the author's dream has become realised, we may be sure that the millenium will have arrived.

KNOWLEDGE: An Illustrated Magazine of Science, Literature, and Art. (London: 326 High Holborn.) Price 6d. monthly,

The March number contains for its first article an illustrated review of Nansen's "Farthest North"; The Victorian Era in Geography, with a plate; The Origin of some Domestic Animals; On Vegetation and some of the Vegetable Productions of Australia, with a plate; Science Notes; Notices of Books, illustrated; Letters; Life History of the Common Tiger Beetle, illustrated; The Chemistry of the Stars, with a plate; The Face of the Sky for March; a Chess Column.

SCIENCE FOR ALL. Edited by Robert Brown, M.A., Ph.D., F.L.S., F.R.G.S., etc. (London: Cassell and Co.) Price 6d.

We have received Part 16 of this most instructive work, which contains papers on the following subjects:—Locusts and Grasshoppers; A Sun-dial; Venus and the Transit of 1882; The Photophone; The Crag; Germs; The Cheese-Grotto of Bertrich—Baden; Right-Handedness; Cohesion Figures; Animals Old and New; Flint; The Optics of a Lighthouse; A Pinch of Salt; Elephants; Cracks in the Earth's Crust. Each article is well illustrated.

BATTLES OF THE NINETEENTH CENTURY. (Cassell & Co.) 7d.
This interesting work was completed with the 24th part. The whole work now forms two handsome and entertaining volumes; to which is added a full index of every person mentioned and incident recorded.

THE STORY OF THE HEAVENS, by Sir Robert S. Ball (Cassell and Co.), was completed with the 18th part and forms a handsome and most instructive volume. There are 18 fine plates and 90 engravings in the text. There is also a carefully compiled index.

EUROPEAN BUTTERFLIES AND MOTHS. By W. F. Roshy, F.L.S., F.E.S.
This grand work has reached its thirty-fourth part; each part contains a beautifully coloured plate. The number before us has life-like representations of seven moths, with their larvæ and food-plants.

CHUMS (Cassell and Co.) is as full as usual of tales of adventure. A new serial tale was commenced in the February part.

THE LEISURE HOUR. (London: 56 Paternoster Row.) 6d. monthly.
The present volume commenced with the Nov. part, besides one or two serial tales. There are a number of very interesting articles, some of those in the March part being A Panorama of London Life; Ruskin's Social Experiment; A Provençal Sketch; Midland Sketches; Future Kings, etc. etc.

THE BOY'S OWN PAPER. (London: 56 Paternoster Row.) Price 6d. monthly.
This volume also began with the November part. Each part contains three serial tales, prize competitions, and a great many other useful and entertaining articles, as, *e.g.*, Electric Toys and How to make them; How to make a Model of a Manual Fire-Engine; Painting in Water-Colour, etc. etc.

HINTS ON STAMP-COLLECTING: An ABC of Philately and Handy Philatelic Guide for Beginners. By J. H. Hinton. 12mo, pp. 53. (London: E. Nister.) Price 1/-
This little book describes—1, The Album and Mounting Stamps in it; 2, Stamps: their Manufacture, Methods of Engraving and Printing; 3, What to Collect. The beginner will find it useful.

SUCCESSFUL ADVERTISING: Its Secrets Explained. 17th edit. By T. Smith and J. H. Osborn. Cr. 8vo, pp. 450. (London: 132 Fleet St.)
Advertisers will find much to interest them in this book, which tells How to become a Successful Advertiser; The Preparation of Successful Advertisements, etc. etc.

THE GOLDEN PENNY. Vol. for July to Dec., 1896. (London: *The Graphic* Office.)
This is one of the popular illustrated weeklies, and contains very readable articles in the shape of Stories, Adventures, Yarns, Sport, Humour, Travels, Inventions, etc. A number of prizes are offered weekly for competition.

British Hydrachnidæ.

By C. D. Soar. Part IX. Plates XII. and XIII.

ALL the species of *Hydrachnidæ* which have been mentioned in my former papers belong to the sub-family Lateroculatæ. The two acarids which will form the subject of this paper belong to the sub-family Medioculatæ (Haller), which contains two genera only :—*Limnocharis* and *Eylais*. Mr. Michael, in his *British Oribatidæ*, page 50, gives a key to the families of the Acarina, in which he includes the *Halicarinæ* with the *Limnocaridæ*, and on page 49 he says :—"I have some doubt about my own correctness in including the *Halicaridæ* among the *Limnocaridæ* ; but I think on the whole that they are fairly placed together."

Now the *Halicaridæ* are Marine mites, or are generally looked upon as such, but I believe several species are found in fresh water. Anyone interested in this family will find a lot of information in a small book by Hans Lohmann, Jena, 1888—*Die Unterfamilie der Halacarides Murr*, which has at the end a Bibliography of sixty-one papers on the subject. At present I have nothing to say about Marine mites, so I will confine the few remarks I have to make to the two genera above mentioned—*Limnocharis* and *Eylais*. Each of these two genera, I believe, are up to the present date only represented by one species each. The distinguishing features of these are so great that they cannot, when once known, be mistaken one for the other, or for any other species of another genus. Both have their eyes near the centre line of the body. Both are red and both attain a large size. In both, also, the mouth organs are modified into a sucker-like tube, but here the similarity ends, for one is a swimming mite and the other is a crawler.

Genus X.—*Eylais*, Latreille.

1796.—*Eylais*, Latreille. *Précis des Caractères des Insectes*, p. 182.

Body, oval; eyes, approximated to the median line of the body ; the fourth pair of legs without swimming-hairs.

It will be seen from the above that the genus we are now about to consider varies very much from those we have previously mentioned. All of the previously noticed Hydrachnids have swimming-hairs to the second, third, and fourth pair of legs, and in some cases to the first; but in the genus *Eylais* the fourth pair are destitute of swimming-hairs, which to a swimming mite would appear to be a very desirable and necessary addition. The fourth pair of legs are strong and very hairy, but are quite without those long hairs we have before noticed. The eyes are also placed very near each other, and not wide apart like the eyes in other Hydrachnids. There is only one other Hydrachnid having the eyes in a central position, and that is the *Limnocharis* mentioned above.

Up to the present I believe only one species is known of this genus, and that is

Eylais extendens (Müll.).

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1793.—*Trombidium extendens.* J. C. Fabricius, *Ent. Syst.*, Tom. II., p. 406, p. 24.

1796.—*Eylais extendens.* Latreille, *Précis des Caractères des Insectes*, p. 182.

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Also *Eylais alutacea*, p. 14, Fig. 20.
Also *Eylais longimana*, p. 14, Fig. 23.
Also *Eylais atomaria*, p. 14, Fig. 19.
Also *Eylais confinis*, p. 14, Fig. 18.

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1879.—*Eylais extendens.* Neuman, *Svenska Handlingar*, p. 105, Twf. XIII., Fig. 4.

1880.—*Eylais extendens.* Murray, *Economic Entomology*, p. 150, Fig. 2.

1882.—*Eylais extendens.* Haller, *Die Hydrach. der Schweiz.*, p. 37, Taf. 11, Figs. 9—13.

1883.—*Eylais extendens.* Griffith and Henfrey, *Micro. Dictionary*, p. 315, Pl. VI., Fig. 28.

1885.—*Eylais extendens.* Krendowsky, *Hydrachnidæ of Russia*, p. 143, Taf. VIII., Fig. 23.

1887.—*Eylais extendens.* Barrois and Moniez, *Cat. des Hydrachnids Nord de la France*, p. 36.

1893.—*Eylais extendens.* Kœnike, Dr. F., *Stuhlman in Ostafrika*, p. 51.

1894.—*Eylais extendens.* Piersig., *Zool. Anz.*, No. 449, p. 215.

1895.—*Eylais extendens.* Koenike, *Die Hydrachniden Ort-Afrikas*, p. 2.

1896.—*Eylais extendens.* Soar, *Sci. Goss.*, Dec., No. 31, p. 170.

The average length of the body is about 4·0 mm.; width, about 3·12 mm.; first leg about 2·40 mm.; second leg about 2·50 mm.; third leg, 3·04 mm.; and the fourth leg, 3·60 mm.; palpi, 1·20 mm.

Shape of body ovate, the smallest end to the front. The dorsal side is well rounded (see Pl. XII., Fig. 1). The epimera are hard, chitinous plates let into the ventral surface, the two first pairs being joined together side by side; the two last pairs touch only at the small ends, the marginal ends where the legs are hinged being wide apart (see Fig. 2). The largest ends of the epimeral plates are also furnished with a quantity of small hairs; a few are also present here and there to about half-way down the epimera plates.

Legs, eight, four on each side, which gradually increase in length from before backward; they are strong and chitinous, and covered with small hairs, the first, second, and third pairs being supplied with swimming-hairs only. The fourth pair, although

without the swimming-hairs, are nevertheless well covered with short hairs, which on the inner edge of the legs are arranged in a line and are stiffer in form than the others. The tarsus is thinner than the other sections of the leg and not quite so long as the preceding internode. The ungues are very small and nearly hidden in the bristles which grow on the extreme end of the tarsi (see Fig. 3). The palpus is five-jointed, the second and third internodes being short and thick, the fourth is longer and more slender; like the legs, the palpi are covered with minute hairs.

Colour, scarlet, some being found deeper in colour than others. Some appear to be very deep in colour in the central portion of the dorsal side and the margin to be much paler. The legs are paler in colour than the body and are inclined to yellow at the joints.

Texture.—With the exception of the epimeral plates the whole surface of the body is soft-skinned. The cuticle appears to be finely striated and not covered with papillæ. I cannot find any external difference to denote the sexes.

Eyes, four, in two pairs, close together. They have the appearance of being connected on the dorsal surface with a small band of chitine, like a pair of spectacles; in colour they are very dark red.

The mouth-organs are very curious. In place of the mandibles, which project and, as a rule, are so conspicuous in other species of water-mites, is a round, sucker-like hole or depression (see Fig. 2).

Distribution.—Very common. I have taken specimens at nearly all the collecting-grounds round London. The greatest number of specimens I have taken in one day was at the Warren, Folkestone, in Aug., 1896.

Larva.—Long in shape and hexapod. On Aug. 26, 1896, I put a few *Eylais extendens* in a tube by themselves. On Aug. 28 a quantity of ova was deposited on the side of the tube of a deep red colour, in a yellow, gelatinous-looking film. On Oct. 2 the larvæ left this gelatinous mass and were free-swimming. They are a deep red colour, like the adults, and seemed to be quite as much at home out of the water as in; but they did not display that eagerness to get out of it that I found with the larvæ of *Diplodontus despiciens* (Müll.). They are very highly cultured, and the hairs on the legs are quite clear, not pectinated. Eyes wide apart,

not close together like the adult. The length of the larva is about 0·48 mm. The form of the nymph is very much that of the adult, only smaller.

The adults vary very much in size, but I have endeavoured to give a mean measure. To arrive at this I have measured about forty specimens. Neuman says the average size is 4 to 5 mm. I have described their usual shape as egg-shaped or ovoid, but I have taken two or three specimens which were quite unelliptical in shape, like Koch's figure of *Eylais confinis.* It may have been this shape which led Koch to think he had found another species. Koch's other figures of *Eylais* appear to be the common shape. So are the figures of Müller, Duge, Neuman, and the little figure in the *Micro. Dictionary.*

In 1885, when *Science Gossip* published those beautifully coloured plates, afterwards discontinued on account of the cost, there appeared a plate by E. T. Draper in January over the name of *Eylais extendens*, which, it will perhaps be as well to point out, is not an *Eylais*, but one of the *Limnesia.* Dr. George, of Kirton-in-Lindsey, pointed this out at the time to the Quekett Club, but I do not think the error was ever corrected in *Science Gossip.* It is a swift and powerful swimmer and easily kept in confinement. I have kept a great number alive in tubes for weeks at the time.

The majority of the references given are merely records of this particular Hydrachnid, having been found at such a place and at such and such a time ; but others are particularly interesting, and should be seen and read by the student in this particular branch of pond life.

Genus XI.—*Limnocharis* (Latreille). 1796.

(Latreille, *Précis des Caractères des Insectes*, p. 181.)

All legs without swimming-hairs ; eyes approximated to median line of body. Body soft and varied in shape.

Limnocharis holosericea (Latreille).

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1755.—Roesel., *Insektenbelustigungen*, III., p. 25.

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1778.—De Geer, *Memoires pour l'histoire des Insectes*, VII., p. 149 —152, Pl. IX., Figs. 15—18.

1796.—*Limnocharis holosericea*, Latreille, *Genera Crust. a Insect.*, I., p. 160.

1804.—*Trombidium aquaticum.* Hermann, *Memoire Apterologique*, p. 35, Pl. I., Fig. 11.

1834.—*Limnocharis aquaticus.* Duges Deux, *Mem. sur l'ordre das Acariens Ann. d. Sc. Nat.*, T. 11, p. 159, Pl. XI., Figs. 35—39.

1835-41.—*Limnocharis holosericea*, C. L. Koch, *Deutsch. Crust. Arachn.*, etc., H. 14, Pl. XXIV.

1842.—*Limnocharis holosericea.* Koch, *Ubersicht*, p. 35, Tab. IV., Fig. 19.

1880.—*Limnocharis aquaticus.* Murray, *Economic Ent.*, p. 148.

1882.—*Limnocharis holosericea.* Haller, *Die Hydrach. der Schweiz.*, p. 34.

1883.—*Limnocharis holosericea.* Griffith and Henfrey, *Micro. Dic.*, p. 471, Pl. VI., Fig. 27.

1885.—*Limnocharis aquatica.* Krendowsky, *Hydrachnidæ of Russia*, p. 138, Twb. VIII., Figs. 24—28.

1887.—*Limnocharis holosericea.* Barrois and Moniez, *Catalogue des Hydra.*, p. 36.

1896.—*Limnocharis holosericea.* Koenike, *Forschungsberichte Biologischen Station zu Plön.*

1896.—*Limnocharis holosericea.* Soar, *Science Gossip*, Dec., No. 31, p. 170.

The mean measurements of body are :—Length about 3·0 mm., width about 2 mm. ; legs:—First leg, about 1·20 mm. ; second leg, about 1·40 mm. ; third leg, 1·60 mm. ; fourth leg, about 1·76 mm.

Colour.—Scarlet. The legs are inclined to yellow at the joints, but the same colour as the body at the other parts.

Form.—I can liken the shape of the body to nothing better than a miniature sack, or bag, of the softest material, and when the mouth-organs are thrust forward the resemblance to the bag is much more striking, it having the appearance of being tied round the top with a string. It is also full of folds, which are constantly changing their position as the little creature moves.

Texture.—The cuticle of the body is very soft, and covered with small round papillæ.

Legs.—In the adult the usual number, eight. These legs have six joints. The first joint is small and almost hidden under the epimera. The other five sections of the same leg are nearly of one length. They are covered with a great number of simple hairs. A few of those on the joints are plumose, but are quite without the long swimming-hairs described before. Each tarsi is fitted with two strong claws, which can be retracted at will into the distal end of the tarsus. The first pair of legs are the shortest.

The epimera is chitinous, with a border of a thicker skin round each epimeral plate, which is fringed with a quantity of fine hairs.

Eyes, four. On the anterior portion of the dorsal surface is an oblong-shaped piece of chitine, which projects on each side towards the larger end, and it is on the margin of these two projections the eyes are situated (see Fig. 8).

The mouth-organs are suctorial. The palpus is short, and reaches no further than the sucker-like mouth. It has hairs at the joints (see Fig. 10).

Distribution.—It is not common. I took two specimens in 1893—one at Woking and one at Sunningdale. In 1894 I took two specimens at The Warren, Folkestone, and one at Redhill. In 1895 I did not take a single specimen. In 1896 I took six specimens at The Warren, Folkestone, and on Sept. the 8th two in North Wales. These last two I have still alive. Seven months since they were captured. I believe both to be females, but they have not deposited any ova.

Larva and nymph I do not know. The adults are very sluggish in their movements, and keep well at the bottom of the water, slowly crawling about amongst the *débris*.

Linneus had priority in naming this mite, and he gave it the specific name of *Aquaticus*, and this name was retained by some of the writers that came after him, as will be seen in the bibliography. I also think myself that the name *Aquaticus* should be kept for that reason. I do not like the alteration of specific names, for the practice leads as a rule to much confusion; but when we get two such well-known writers on the *Hydrachnidæ* as Koenike and Piersig—both of whom call it *holosericea* after Latreille—I must submit to their ruling and say no more on that question.

EXPLANATION OF PLATES XII. AND XIII.

Fig. 1.—*Eylais extendens.* Dorsal surface.
,, 2. ,, ,, Epimera and mouth-organs.
,, 3. ,, ,, First leg.
,, 4. ,, ,, Dorsal surface of larva, legs removed.
,, 5. ,, ,, Last joints of the first leg, showing the peculiar claw.
,, 6.—*Limnocharis holosericea* Dorsal surface.
,, 7. ,, ,, Ventral surface.
,, 8. ,, ,, Eyes.
,, 9. ,, ,, First leg.
,, 10. ,, ,, Mouth-organs and palpus.
,, 11.—*Eylais extendens.* Appearance of the ova as deposited on the side of the tube.

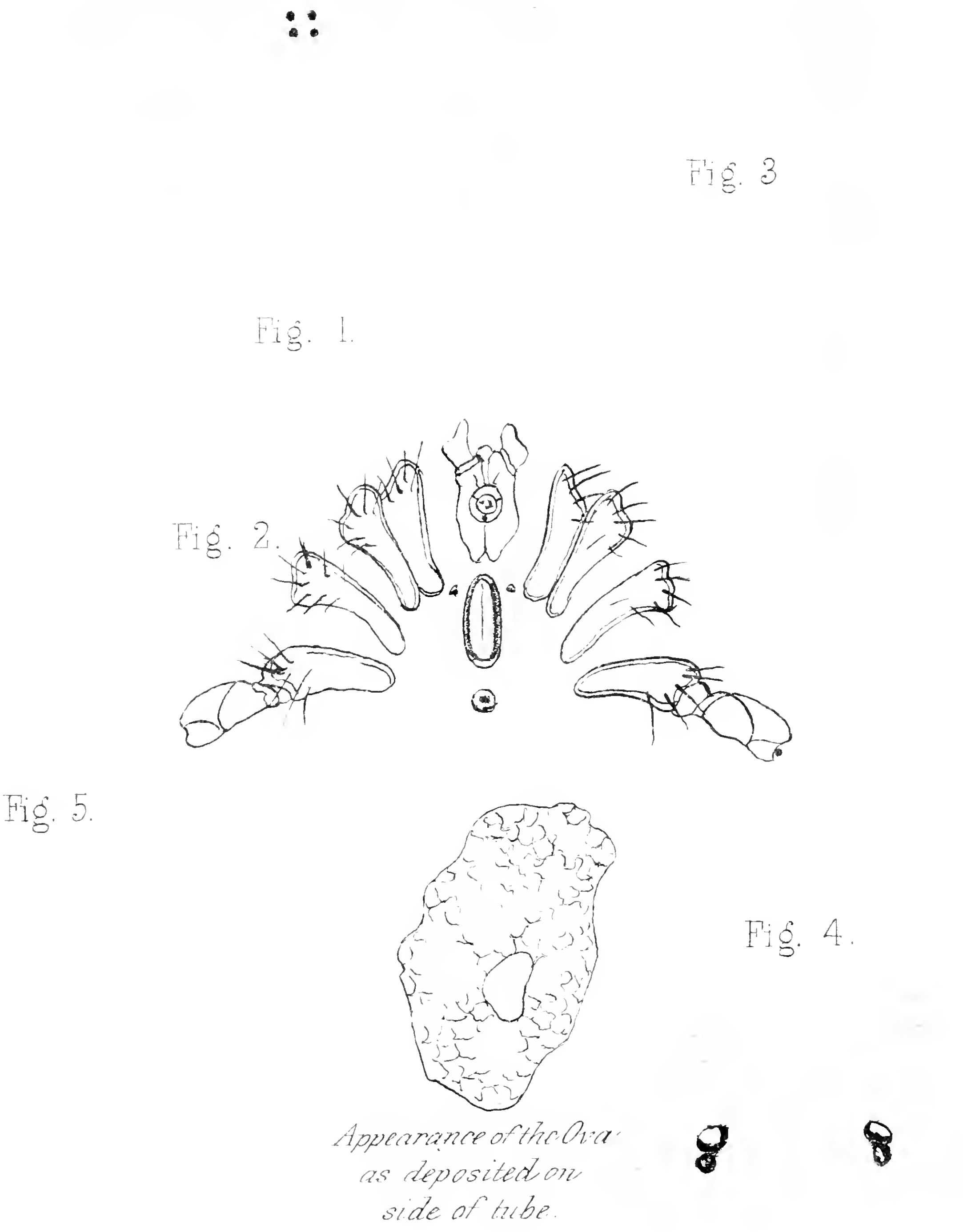
A Method of Staining Flagella.

By David McCrorie, L.R.C.P. and S. Edin., F.E.I.S., etc.*

Of the different methods of staining flagella which have at different times been described, Van Ermengen's, in my experience, gives excellent results, but takes too long to accomplish ; while Loeffler's, as well as Nicolle and Morax's modification of the same, is very uncertain. Pitfield's method gives good results, and is quickly accomplished, but the flagella are, as as a rule, very faintly stained. The method which is now commonly adopted in this laboratory is somewhat similar to Pitfield's, but we use a different stain, and invariably we get both bacilli and flagella more distinctly stained than by Pitfield's method. The dye we use is an aniline blue, which is known commonly as "Night Blue," from the fact that it shows as well in artificial as it does in sunlight. The formula which we find to give the best results is—

10 c.cm. of a concentrated alcoholic solution of "night blue."
+10 c.cm. of a 10 per cent. solution of alum.
+10 c.cm. of a 10 per cent. solution of tannic acid.

* From *British Medical Journal.*



Eylais extendens.

Chas. D. Soar ad nat. del. F. Phillips Sc.

Journal of Microscopy 3rd Ser. Vol. 6, Plate. 13.

Fig. 6.

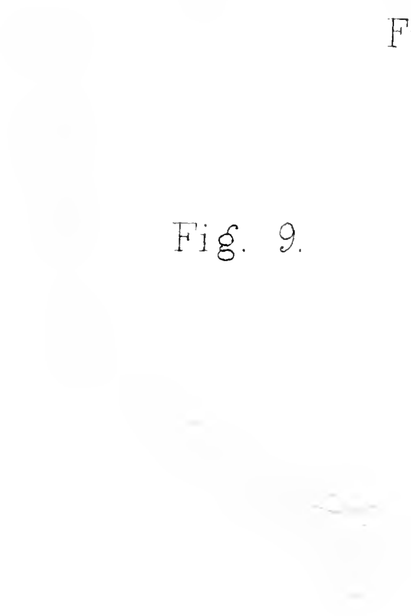


Fig. 9.

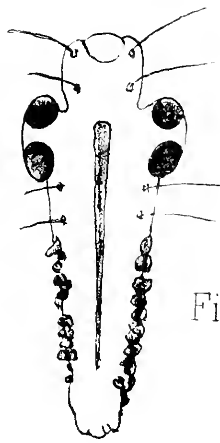


Fig. 8.

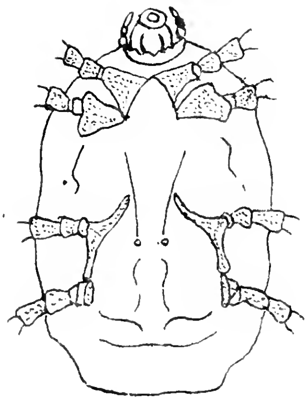


Fig. 7.

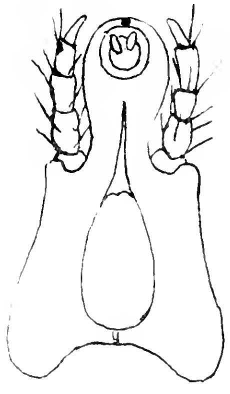


Fig. 10.

Limnocharis holescricea.

Chas. D. Soar, ad nat del. *F. Phillips Sc.*

The addition of 0·1 to 0·2 g. of gallic acid would seem to add to the value of this mordant stain, but excellent results can be obtained without this addition.

The method we adopt is this :—A drop of sterilised water is placed on an absolutely clean cover-glass, held in a Cornet's clip, and carefully inoculated with the smallest quantity of a twenty-four-hours' agar culture. The cover-glass is moved in such a way that the drop of water is distributed over nearly its whole surface, or a suspension may be made in a watch-glass and a thin film spread upon a cover-glass. It is then placed in the incubator until thoroughly dried (two minutes). A small quantity of the mordant stain is then poured on, and the cover-glass again placed in the incubator for two minutes, or held for that time two feet above the flame of a Bunsen burner. The excess of stain is now washed off by running water, the cover-glass dried in the incubator, and then mounted in Canada balsam. The mordant stain can be used either filtered or unfiltered; it does not necessarily require to be made fresh each time, as we find that the stain is quite as efficient after a fortnight or so as on the first day of use. The whole process can be accomplished in a few minutes.

Poisoning by Caterpillars.—Girard, a veterinary surgeon, at Barnewet, has observed numerous fatal cases of poisoning in ducks after eating caterpillars, notably those of *Pieris brassicæ*, the large white cabbage butterfly. About six hours after eating these larvæ, poisoning became evident, diarrhœa and staggering grit, followed by dyspnœa, and ultimately death. Autopsy showed the essential lesions to indicate inflammation of the digestive tube. It is probable that these symptoms are caused by the inflammation produced in the alimentary canal by the very minute hairs with which this caterpillar is covered. It has been noticed that chickens invariably refuse the larva of *P. brassicæ*, although they greedily devoured the smooth larvæ of the various Noctua.—*Phar. Jour.*

Saturn.

By H. J. Townshend.

SATURN, during the months of May and June, 1896, presented the appearance of a dull, yellowish, first magnitude, starlike object in our southern heavens, in a region barren of stars to naked-eye vision, about 14 degrees obliquely south of Spica. This wonderful planet is the sixth in order outwards from the sun, but is the second in size of the primary planets. In appearance, to the casual observer, this great globe is reduced to a mere point of light by his enormous distance from the Earth. It is almost incredible that such a tiny point of light should contain within itself a system as vast as it is unique; but just as the small, dark speck on a microscope slide may be the centre of a complex organism, invisible in all its exquisite structure to the naked eye, but rendered clearly apparent in all its intricate beauty with the aid of a powerful objective, so is that marvellous ringed system of Saturn as seen through a good telescope.

On May 5th, 1896, at nine hours, Saturn was in opposition, and was then distant from the earth some 825,080,000 miles, being at his nearest approach for the year, and was consequently at his best to be seen and examined, though, unfortunately, low down toward the horizon, and often obscured by clouds and smoke. At the present time, Saturn is practically useless for observational purposes, for our own Earth, in her annual journey around the sun, has reached a point in her orbit about opposite to that where she was on May 5th, 1896, placing Saturn in the position known as "in superior conjunction"—the actual date and time being the 13th instant,* at two hours—or, in other words, in a line with the Earth, but beyond the sun; hence we have increased the distance between us by the diameter of that section of the Earth's orbit, less the difference caused by the elevation of Saturn of $2^\circ 10' 43{\cdot}8''$ above the plane of the Earth's centre. (Here a diagram was referred to, showing the distance for the 13th instant between Earth and Saturn, as taken from the logs of the nautical almanac,

* This paper was written in November, 1896, and read before the Leeds Astronomical Society.

working out at 1,014,322,100 miles, whereas if Earth and Saturn were in a direct line with the sun's centre, there would have been the greater distance of 61,804 miles). While Saturn is now actually elevated above the plane of the Earth's orbit, the plane of his rings is much lower because of their great tilt, and so we are at present looking upon the northern side of the ring system, which will continue until 1899, when they will extend beyond the two poles of the ball, and be at their widest opening, and the planet will then be 20° in Saggitarius; at present he is in the sign of Libra.

The diameter of the ball of Saturn, according to Professor E. E. Barnard's latest micrometrical measurements, is 76,470 miles equatorial and polar 69,770, so that the polar compression would seem to be 1—11·42; therefore the volume of Saturn follows at 822 times that of our Earth.

Saturn requires nearly 29½ of our years to complete his annual journey of almost 5,559¾ millions of miles around the sun, at an average speed of 5·95 miles per second; so that while he sways once around his mighty orbit, our comparatively small globe, that is flying through space at a rate of over eighteen miles per second, is completing its thirtieth revolution, or year; but a day with us equals 2⅓ of Saturn's days! This latter difference arises from the rapid axial rotation of the great planet, which turns completely around once in every 10h. 14m. 30s., while we rotate once in 23h. 56m. 4·09s. The equatorial circumference of Saturn is no less than 241,040 miles, as he is seen from limb to limb, or over ten times that of the solid Earth; so that while matter is carried around at our equator at the rate of about 1,000 miles per hour, matter at Saturn's equator will be whirled around 23½ times faster, or 23,560 miles an hour. This surface velocity at Saturn's equator is strong proof in favour of his being in a highly heated condition, as suggested also by his low mean density, the lowest known in the Solar system. His seasons, for such there must be, judging from his axial pose of 26° 43′ 23″ to the plane of his orbit, we cannot possibly picture what they are like. Their lengths, we can say, must each cover a period of over seven of our years, and that from the Saturnian autumnal to vernal equinox there must be an interval of nearly fifteen of our years.

The disc as seen is not necessarily the ball that forms the solid,

or great mass, of Saturn. There may be an atmospheric shell of extreme tenuous gases, but capable of carrying sparsely strewn clouds surrounding a heavier nucleus, or how shall we account for the various markings seen to cross his face, and these not permanent, for they have been followed in their changing aspects, and so have helped to a determination of the planet's rotation? The equatorial bright zone has disclosed the presence of white spots, or areas, as if it were hot matter that had been flung up from within. Two of these white areas are shown in the drawing as seen on May 5th, 1896, at 12h. One appears to have been about $2\frac{1}{2}''$ and the other about $4''$ in diameter, or about 10,000 and 16,000 miles each respectively in horizontal diameter. Dark spots, too, were seen in the N. temperate belt. A bright margin to preceding limb was also seen and noted as the brightest portion of the planet; indeed, it could be described as luminous, almost suggestive of a highly reflective atmosphere. This bright margin was estimated at about $\frac{1}{2}''$ of arc in width, equalling about 2,145 miles. Spectroscopic examinations by Huggins show an atmosphere to Saturn similar to that of Jupiter, while Janssen's indicates an aqueous vapour. Vogel's spectrum analysis shows more atmospheric bands on the ball than in the rings. Many of the varying features and fluctuations of light noticeable on Jupiter's disc are to be seen in Saturn's case; but, of course, more feeble and difficult to glimpse, as from the greater distance of Saturn from the Sun the centre of his disc receives not quite one-third as much sunlight as does the centre of Jupiter's disc.

The excentric position of the ball of Saturn was next referred to and shown in the drawing. While the top of the inverted image could not be seen with certainty above or over the rings, the bottom, or N, certainly protruded beyond, showing a northerly displacement, it was thought, of about $\frac{1}{2}''$ of arc, or equal to 2,145 miles. This excentricity of the ball is thought to be mathematically possible. The distance of the limb of the planet from both ansæ, it is said, has been seen to differ as much as $\frac{1}{2}''$ of arc, or, in other words, the space between the ball and the rings on the eastern side has been found to measure some 2,145 miles wider than on the western side. Galle, in 1684, was the first to observe that the ball was not placed centrally in the rings, though he

claimed that the western side was the widest; but Schwabe and the Roman observers considered the excentricity of the ball rapidly variable in 1842 and 1843.

It is one of the prettiest sights in the heavens to see the circle of light girdling the ball, as it sweeps silently and swiftly across the field of view. According to Professor E. E. Barnard's latest micrometrical measures—the results of two years' observations—the outer diameter of the outer ring was found to be equal to 172,310 English miles; while the width of the A, B, and C rings, Otto Struve's designation of the three principal rings, including the divisions in them, represent 42,060 miles; then comes the space of 5,860 miles on either side of the ball, which, with the latter measuring 76,470 miles across, equatorially, make up the grand total as stated above. This unique and stupendous series of bands of illuminated, and probably solid but separate particles, baffled the scientific world for a long time. Prof. Clerk Maxwell solved the problem mathematically by advancing the theory that the rings were made up of myriads of meteoric bodies, each pursuing its own independent orbit around its centre. Professor Keeler has since announced a variability in the velocity of different parts of the rings, as disclosed with the aid of his spectroscope; and E. M. Antoniadi's recent observations further strengthens Prof. Clerk Maxwell's deductions, for the latter gentleman claims to have seen the outer edges of the A ring broken up, and showing whitish areas, or markings. On the night of May 5th, 1896, with fine definition, I also saw the outer edges of the A ring, similar to that shown in my drawing, giving the appearance of being broken up and fragmentary, and darker than the inner portion.

It is thought quite possible that Mimas, the innermost satellite, travelling at a distance of only 30,595 miles from the surface of Saturn, may cause a variability in the velocities of the outer members, or small bodies that constitute the ring system, and some of these synchronising with the motion of Mimas, when near to the place of the satellite, would create gaps, or intervals, of varying distances, causing the fluctuating features suspected in that section of the ring. The "B," or central, ring is the broadest and brightest in the system, and E. M. Antoniadi has announced a new division in it, with two fainter ones on either side. The "C," or

crape, ring was seen by me very clearly during the last opposition, and it certainly extended from the inner edge of the "B" ring, nearly, if not quite, half-way toward the ball. It is considered that this ring is tending inwards, and that the small bodies that probably belong to it are falling down into Saturn's atmosphere, appearing in it somewhat similar to shooting stars, or meteors, that plunge into our atmosphere, and that their places are being taken by members from the nearest parts of the next ring. The present appearance of this marvellous ring is that of an exquisitely delicate piece of gauze-like, golden, and dark purple material, so slender as to baffle a fair description of it.

This mysterious ring was first seen by the astronomers of the Roman Observatory in 1828, but they did not report it at the time. Dr. Galle, of Berlin, in 1838, saw it, and measured it for the first time, but his observations were carelessly shelved in the Berlin Observatory. It was left to Professor G. P. Bond, in 1850, to rediscover this curiously interesting structure, and to announce it to the world; while Mr. Dawes independently detected it eighteen days later, in ignorance of Bond's discovery, the announcement of which had not then reached England. Close observations of this "C" ring have continued since 1850, and it has been found to vary in its aspects and inner outline, as well as its changing angular position.

The thickness, or comparative thinness, of the rings as a whole is estimated at considerably under one hundred miles, probably less than one-half that, but the "B" ring is thought to be thicker than the outer or "A" ring, because of the convexity of the shadow said to have been seen cast by the ball on the rings. This shadow is also said to have been seen concave after opposition! Such a variation suggests refraction of light as the probable causes of difference. If Saturn shone by inherent heat, and the rings reflected his light only, then they would be lit up all around right up to the ball on either side, and no shadow at all would be seen, as is always the case now, both before and after opposition; thus proving that the whole system shines by reflected sunlight.

Saturn has eight attendant moons that may be compared with the sun's eight attendant primary planets. It is strange that the main outline of the solar system should be repeated within itself

in miniature. These Saturnian satellites are almost indescribable as tiny light points, even when seen under a high power telescopically, nor is this surprising when we remember the vast difference that separates us from such comparatively small objects! The wonder is that we can glimpse them at all in the feebleness of their reflected lights, and it is by their light-power that their diameters are estimated.

What a mighty pendulum-like sweep has Japetus, the outermost satellite of the mighty Saturnian system, swinging around his centre from side to side over a distance of 4,471,460 miles—nearly twice as great as that of the Jovian assemblage. Let us wing our flight in imagination away to the night side of Japetus, and picture the great globe of Saturn encircled with that mighty ring of light, floating before our gaze, amid the star-spangled, myriad-orbed, ethereal expanse. What a spectacle! an arc of soft light moving athwart the sky, measuring probably some 5° across, or equal to about ten of our full moons in diameter; but, of course, of more feeble light. Can all this wonderful creation serve no useful purpose? One feels compelled to think that all the wisdom in such a design must have a corresponding use, and that life in some form or of some kind fitted to its environment is there, in some one or more parts of the system. Our able astronomer, the late Mr. Procter, inclined to the opinion that the moons of Saturn did not serve the purpose our moon does to us, as lamps to light the Saturnian nights, but rather that they were possibly places of habitation. If this is so, then the conditions there must be the very antithesis of our surroundings here; but Saturn does not seem to be in that sun-like stage, glowing with heat and light necessary to the existence of life as we know it. Yet life there may be, peculiar to itself and place, which is a problem as yet unsolved, and probably unsolvable by man.

THE lowest temperature thus far attained is 264° below zero Celsius, which Prof. Olazewski employed in his experiments with the liquefaction of helium. According to this investigator, helium can be used for filling thermometers which are employed for measuring very low temperatures.—*Pharm. Era.*

A Rapid Method of Fixing and Staining Blood-Films.

By G. Lovell Gulland, M.A,, B.Sc., M.D., F.R.C.P.E., etc.*

THE method by which permanent microscopical preparations of blood are made is generally that devised by Ehrlich or one of the numerous modifications. These methods all involve the preliminary drying of the blood-film on the cover-glass. The hæmatoxylin of the red corpuscles is then fixed, either by prolonged heating to between 110° to 120° C. as in the original method, or by treating the dried film with alcohol and ether, corrosive sublimate, or some other fixative. The process, in any case, is long and troublesome. Muir's method,† in which the films are fixed without drying by dropping them into a saturated solution of sublimate, was a great advance, inasmuch as it gives a much more accurate fixation of leucocyte structure than can ever be obtained by drying, while the red corpuscles, though they often show a certain amount of shrinkage, are less deformed than by Ehrlich's method. But the process is a long one if it is carried out as advocated by Muir, whilst if, in the attempt to shorten it, the washing out of the sublimate is not thoroughly done, crystals are apt to appear in the finished preparation.

It has been my aim, therefore, for some time past, to discover a method which should give an accurate fixation, which should be as rapid as possible, and which should yet be sufficiently flexible to prevent preparations being spoilt by even considerable deviations from the exact method. The last point is essential if the method is to be of use to practitioners who are not specially skilled in microscopical technique. I trust that this will be the case, for I am convinced that many interesting blood-cases go unrecorded for want of an easy way of staining and preserving blood-films.

In its most rapid form the process is as follows:—A small drop of blood, drawn in the usual way, is taken upon the centre of the cover-glass held with forceps, and distributed evenly between that

* From the *British Medical Journal.*

† *Journ. of Anat. and Physiol.*, Vol. XXVI., 1892.

and another cover. The utmost care must be taken to avoid all pressure, as the after-appearance of the red corpuscles depends almost entirely upon the way in which the manœuvre is carried out. The covers are then gently and rapidly slid off one another, and dropped with the wet side downwards into the fixing solution. This is made up of:—

Absolute alcohol saturated with eosin	... ...	25 c.cm.
Pure ether	... ...	25 c.cm.
Sublimate in absolute alcohol (2 grm. to 10 c.cm.)	...	5 drops (more or less).

The quantity required for use at one time, which may be 5 to 10 c.cm. for four cover-glasses, should be poured into a wide-mouthed bottle or flat dish, and may be used several times over if it be preserved from evaporation. (I generally keep the thin liquids in different bottles, and make up the required amount in the above proportion before using it.) The fixation of the elements is practically instantaneous, but the cover-glasses should be allowed to remain in the solution for at least three or four minutes to fix the film to the cover. They are then taken from the solution by forceps (steel forceps will do), and wash rapidly but thoroughly by waving them to and fro in a small basin of water. They are then stained for one minute (not longer) in a saturated watery solution of methylene blue, and again rapidly washed in water. Next, they are quickly dehydrated in absolute alcohol, which at the same time removes the excess of methylene blue, cleared in xylol, and mounted in xylol balsam on a slide.

The whole process need not occupy more than six or seven minutes; but, on the other hand, any portion of it may be prolonged without injury to the specimen. The fixation may be continued for twenty-four hours and the washing for the same time; but if the staining with methylene blue be prolonged for a minute or two, it becomes necessary to use an inconveniently large amount of absolute alcohol to remove the excess of the stain, and the eosin is apt to be washed out at the same time. The red corpuscles are stained pink, the nuclei a deep blue, the bodies of the leucocytes in varying shades of pink; the eosinphile and basophile granules in the leucocytes are well brought out; the blood-plates are stained a fainter blue than the nuclei, and organisms are also well stained.

This is simply the most rapid clinical form of the method. Any other acid stain which is soluble in alcohol and not precipitated by sublimate may be used instead of eosin, and the stain may be omitted from the fixative altogether, so that the cover-glass specimen, after fixation in the alcohol-ether-sublimate, may be stained in any way that is desired.

The method is no less useful for fixing pus, sputum, and anything else which can be spread in a film; only with these it is generally advisable to prolong the fixation. The cover-glasses used must be scrupulously clean. The simplest way of insuring this is to put them for a few minutes in glacial acetic acid, then wash them with plenty of water so as to remove the acid thoroughly, and dry them with a fine handkerchief. A large quantity should be treated at one time and stored up.

The thinner the film the better the fixation. As it is not possible in specimens mounted in balsam, by whatever method, exactly to reproduce the appearance of fresh corpuscles, as seen in freshly drawn blood, it is desirable to control balsam preparations by examining fresh blood, or, still better, by pricking the finger through a drop of 2 per cent. osmic acid solution and examining the preparation thus made in a fluid mount. This is especially desirable where the red corpuscles are altered in shape to a slight extent; greater degrees of poikilocytosis can easily be made out in balsam preparations.

Plant Chemistry.—Of the seventy elementary substances recognised by chemists, only thirteen contribute to the formation of vegetable substances. Out of this baker's dozen all the varied forms of leaf, flower, and fruit are fashioned. Of these thirteen organic elements, three make up more than nine-tenths of all cultivated plants. These are carbon, oxygen, and hydrogen—carbon and water. While these make up the largest part of plants, they are not classed as manures, because they are not applied by hand, but come to the plant from the atmosphere in the form of carbonic acid and rain. They are Nature's free gift to plant life, and are borne on the wings of every wind that blows and the clouds that float aloft.—*Journal of Horticulture.*

Parasites.*

By Charles Hoole.

THE study of Parasites is one which is viewed by many minds with a considerable degree of repugnance; but on closer acquaintance (not too close) that repugnance will be found to give way to interest and admiration, and, as Boyle has well said, "Nothing can be so minute as to be unworthy of the investigation of man, which was not unworthy of being created by God."

Now, as to the meaning of the word "parasite." In ancient Greece the *parasitos* was a priest or minister of the gods, whose duty was to collect from the husbandmen the corn set apart for public sacrifices and to superintend those sacrifices. The storehouse in which this corn was deposited was called *parasiton*. In the Athenian villages certain of these parasiti, who were connected with the worship of Hercules, were maintained at the public expense; but to ease the country of this burden the magistrates at length compelled some of the more opulent class to take them to their own tables and entertain them at their own expense. Hence the word "parasite" came to mean one who frequents another's table, or a hanger-on.

Parasitism, in its widest sense, may be taken to mean the dependence of one species of animal or vegetable upon another for nourishment or shelter, or both. Animal parasitism may be lifelong or temporary. Some parasites are free whilst young, some when old, and some migrate and undergo metamorphoses. Others, which have been called messmates, or commensals, only require a place at their host's table, and inflict no injury upon him beyond helping themselves to his food, and in some cases even rewarding his hospitality with some benefit in return. Again, these messmates may be either free or fixed, in the latter case losing their organs of locomotion and even of sense, and casting their lot for life with their hosts—for instance, the Cirripedes found on whales, crabs, etc.

The parasites which feed on their host's body have been divided into *Epizoa* and *Entozoa*—external and internal parasites. The

* Read before the Sheffield Microscopical Society, March 3rd, 1897.

Epizoa infest the skin of their hosts, and in the case of man and other mammals suck his blood—such, for instance, as mosquitoes or gnats, fleas, lice (three or four species), with small *suctorial mouths*, and a bug. In the case of the biting, or bird lice, they have *biting mouths* furnished with mandibles and hooked maxillæ to suit their mode of life, as they do not suck the juices of their hosts, but feed upon the tegumentary appendages. Sometimes these biting or bird lice are found on mammals. One of the most familiar is the dog-louse, *Trichodectes latus*. Some mites may also be included with the external parasites.

In many parasites the male is free all his life; but the female, while free when young, seeks a host when she becomes sexually mature. Such are chiefly Epizoans, as the Lernæas and fish-lice. Many parasites, especially tape and thread worms, have two hosts, the intermediate one being generally an herbivorous animal, which swallows the parasite either in the egg or whilst young; and the final host some carnivorous animal, which feeds upon the intermediate host, and which swallows with it the contained parasite. The parasite, on reaching its final host, generally undergoes a change of form and becomes sexually mature, inhabiting chiefly the alimentary canal and its outgrowths, so as to apply for a ready exit for the eggs. Most parasites are introduced into the system through the medium of meat and drink. The most terrible of man's parasites are the *Trichina spiralis* (which causes the disease known as trichinosis) and the tape worms, in meat insufficiently cooked.

It is believed that mosquitoes imbibe embryo *Filariæ* with the blood of man, and that many of these reach full development within the mosquitoes, acquiring their freedom when the latter resorts to water, where it dies after depositing its eggs. Mosquitoes are thus the means of introducing the *Filariæ* into the human body through the medium of water.

Certain parasitic flies lay their eggs within reach of the tongues of horses, and by which means they are conveyed into the stomach. Other insects, as the Ichneumon flies, pierce the bodies of caterpillars by means of their ovipositors, and insert their eggs, which hatch into fat larvæ, and devour their hosts'

internals, leaving the vital parts untouched, until there is no longer any necessity to prolong the life of the victim.

I now propose to say a few words on the mouth parts of the parasites which are free during their whole life :—the mosquitoes or gnats, fleas, human lice, and the *Mallophaga*, or biting lice. In these creatures, except the *Mallophaga*, a puncture is made by a combination of perforating lancets (if they may be so called), which constitute the mouth-organs, and which, when combined, form a sucking-tube, through which they draw up the juices of their prey for their nourishment. This act is usually followed by pain, swelling, and inflammation; but it is not known whether these discomforts are caused by actual poison or by an irritating action of the saliva; at all events, no poison-glands are discoverable. Of course, these wounds may occasionally be inflicted for protective purposes, as well as for a means of procuring food.

In the mosquitoes, or gnats, the blood-sucking propensity belongs only to what we usually term the gentler sex, the males being innocent and inoffensive (as far as animals are concerned), and all the virulence being found only in the female mouth. To this rule the fleas and bugs form an exception (and also the lice?). In them both sexes possess and use the piercing apparatus.

The mouth-parts in the gnat are seven in number. The most conspicuous is the labium – a long, flexible organ proceeding from the front of the head and deeply grooved on its upper surface for the reception of the others, and covered with hairs and scales. The anterior extremity is divided into two lobes. The six remaining parts consist of the labrum, which is stouter than the remaining organs and grooved. It serves to direct and protect the other five, which consist of a pair of mandibles furnished at the tips with saw-teeth and a sharp point, a pair of similar but more slender organs having thin blades, and a back without teeth, representing the maxillæ, to the base of which the palpi are attached; and a very fine instrument, ribbed up the middle, and traversed by a tube, terminated by a somewhat spear-shaped head—this represents the tongue.

When the female attacks her prey, she places the lobes of the labium upon the spot selected, and the piercing-organs enter the skin, being guided and supported by the labium. As they pene-

trate the flesh, the labium becomes more and more elbowed, so as to shorten it, without ceasing to support the piercing parts. When these acts have been completed, the creature proceeds to draw the blood into its mouth, the sucking bulb of the œsophagus (which is furnished with a valve) acts, and the victim makes a few cursory remarks which scarcely come within the scope of this paper.

According to the accounts of travellers, these pests seem to be almost omnipresent, extending from the tropics to the poles. Brehm, in his interesting book, *From North Pole to Equator*, gives a most graphic account of the mosquitoes of the "tundra" around the North Pole. He says:—"To call it the most important living creature of the tundra would be scarcely an exaggeration. It enables not a few of the higher animals, especially birds and fishes, to live. It forces others, like man, to periodic wanderings, and it is in itself enough to make the tundra uninhabitable in summer by civilised beings, Its numbers are beyond conception; its power conquers man and beast; the torture it causes beggars description." He goes on to say:—"If an observer can so far restrain himself as to watch them at this work of blood, without driving them away or disturbing them, he notices that neither their settling or moving about is felt in the least. Immediately after alighting they set to work. Leisurely they walk up and down on the skin, carefully feeling it with their proboscis; suddenly they stand still, and with surprising ease pierce the skin.

"While they suck, they lift up one of the hind legs and wave it, with evident satisfaction, backwards and forwards—the more emphatically, the more the translucent body becomes filled with blood. As soon as they have tasted blood they pay no heed to anything else, and seem scarcely to feel, though they are molested and tortured. If one draws the proboscis out of the wound with forceps, they feel about for a moment, and then bore again in the same or a new place; if one cuts the proboscis quickly through with sharp scissors, they usually remain still, as if they must think for a minute, then pass the forelegs gently over the remaining portion, and make a prolonged examination to assure themselves that the organ is no longer present. If one suddenly cuts off one of their hind legs, they go on sucking as if nothing had happened, and continue to move the stump; if one cuts the blood-filled body

in half, they proceed, like Münchausen's horse at the well, but at length they withdraw the proboscis from the wound, fly staggeringly away, and die within a few minutes."

I may add that the late Henry Seebohm told me on his return from Siberia that he was very much troubled by the mosquitoes settling on his gun-barrel when he was about to fire, rendering it most difficult to take a careful sight.

Heredotus also relates (*Enterpe*, XCV.) that the Egyptians, who lived in the marshy grounds, used to sleep under their fishing nets in order to escape from the attacks of gnats, of which he tells us there were surprising numbers.

The gnats have aquatic larvæ and pupæ. The eggs are laid on water and the larvæ float at the surface, head downwards, so that the respiratory organ, which is at the other end and contains two air-tubes, is flush with the level of the water, and feeds and breathes uninterruptedly. When it passes into the pupal form, the position is reversed. It floats head upwards and breathes through two trumpet-shaped organs attached to the thorax. The gnat belongs to the sub-class *Holometabola*, having a complete metamorphosis, the larva, pupa, and imago differing much from one another.

The fleas of which I am about to speak also belong to the same sub-class, having a complete metamorphosis.

In the flea, the mouth-parts consist of a lingua, which may be taken to represent the upper lip, and two mandibles with a central rib, and serrated edges, protected when at rest by the labial palpi, and which unitedly form the piercing apparatus, thus constituting a tubular haustellum. There are also maxillæ at the sides of the mouth, of a somewhat triangular form, furnished with rather large five-jointed palpi, which have been mistaken for antennæ. The antennæ are usually carried in receptacles at the back of the eyes, these receptacles being covered by movable valves. At times the antennæ may be withdrawn from their cavities. The lingua is toothed on the upper surface and traversed throughout its entire length by a canal, which gives off smaller ones, terminating at the end of the teeth, thus constituting the suctorial organ. On most of the fleas infesting the lower animals one or two pectinate fringes are found. On the dog-flea, one is on the lower part of the head

and another on the prothorax. On the flea of the hedgehog the fringe is found on the mesothorax.

Theobald, in his *British Flies*, points out that the three segments of the thorax are very distinctly marked. On the second, or mesothorax, is the first pair of scales or rudimentary wings, and on the metathoracic segment we find the large scales representing the halteres of the diptera. He goes on to say:—"This is a point worth noticing, that the posterior rudiment is more developed than the anterior, contrary to the usual arrangement in flies."

In most of the fleas from various animals which I have examined, the mouth-parts appear to be almost identical, the piercing instruments being about the length of three and a-half joints of the maxillary palpi; but in a female one from the badger they are fully half as long again.

The Pulicidæ are divided into three genera, and number thirteen species in all. Their geographical distribution, like the gnats, reaches from the Arctic regions to the equator, but they seem to flourish best in warm climates; and, unlike the gnats, the male is as eager for blood as the female. There is another flea (*Pulex penetrans*), commonly called the Chigoe, or Sand flea, which is very troublesome in South America, the West Indies, and on the West Coast of Africa. They burrow into the flesh, and if not carefully removed, in time lay their eggs under the skin, causing very serious ulcerations. I have not been able to procure a perfect specimen, but received the head of one from Trinidad, and mounted it.

The true lice belong to the sub-class *Ametabola*, order *Anoplura*, the young not passing through a metamorphosis, and differing from the adult chiefly in size. They are destitute of wings, have two simple eyes, and are parasitic on mammals. The rostrum is retractile, concealed beneath the head, when at rest, consisting of a soft tubular sheath, dilated at the end, armed with a double row of small horny hooks, from the centre of which proceed four bristles converging at their points, and forming a tube adapted for suction. Their eggs are known as nits.

In the ordinary head-louse the legs are all formed for climbing. The claws at the extremity are exceedingly strong, and can oppose each other so as to give a very firm hold on hairs, etc. They are not at all well adapted for walking—a specimen was given to me

alive, and on placing it for observation on a smooth earthenware saucer I noticed that it did not get on very well, but on presenting it with a hair it immediately grasped it and appeared much more at home. The claws of the female are similar, but more slenderly formed and finer pointed. In the male body or clothes' louse the claws are similar to those of the female head-louse, and in the female more slender; and in the crab-louse, in each sex, the anterior legs appear to be more adapted for walking, but the hinder four are exceedingly robust, and well adapted for grasping and climbing. The mouth parts in each of these three varieties appear to be very similar, and also in the genus *Hæmatopinus*, which infest some of the lower mammals.

We now come to the *Mallophaga*—the biting, or bird lice.

In these the metamorphosis is very slight. They creep about near the surface of the skin, amongst the hairs and feathers, and usually do not come to the surface, so that they are not readily detected. Most of them live on birds and have generally two claws to the feet, whilst those infesting mammals have mostly only one. The mouth parts are on the under-side of the head. The upper lip is frequently of a remarkable scraping form and the mandibles toothed for cutting. Most of them have small forelegs, usually drawn towards the mouth to manipulate the food, so that sometimes the body looks as if it had only four legs. It should be noted that these *Mallophaga*, though called bird-lice, are quite distinct from the true lice, which, as I pointed out before, live by suction, though they are often found with them, and it may be added that, in a state of nature, it is believed they rarely cause any annoyance to their hosts.

I must apologise if I have been too reiterative in my descriptions, but my object has been to describe plainly the mouth parts and the method of using them by the aforesaid parasites.

THE rapidity with which Plant Lice multiply is marvellous, and perhaps not sufficiently recognised. According to the calculations of one great scientist, five generations proceeding from one mother produced 5,904,900,000 in a season, and as many as forty generations have been known to proceed from one mother.

A Modification of Heller's Method of Staining Medullated Nerve Fibres.

By W. Ford Robertson, M.D.*

IN the *British Medical Journal*, Nov. 28th, 1896, in the course of a report of a meeting of the Manchester Pathological Society, a short account was given of Heller's method of staining medullated nerve fibres, on the subject of which a communication had been made by Dr. R. T. Williamson. I had for some time previously been making observations on the staining action of osmic acid upon nervous tissues, hardened in the chrome alum-copper fluid used in Weigert's new method for neuroglia. After reading the description of Heller's method, which is carried out upon sections of tissue hardened in Müller's fluid, I applied the same staining process to the tissues with which I had been experimenting. The results obtained were most striking, the medullated fibres being deep black, and standing out with extraordinary distinctness on a practically colourless ground. I have carefully compared these preparations with others made according to the original Heller's method, and there can be no question of their superiority, the medullated fibres being much darker, the other tissues more thoroughly bleached. It therefore seems desirable to publish an account of this modification.

Weigert's chrome alum-copper fluid is composed of:—Chrome alum, 2½ per cent. ; copper acetate, 5 per cent. ; acetic acid, 5 per cent. ; formalin, 10 per cent. The chrome alum is boiled in the required amount of water, and when dissolved the acetic acid and copper acetate are put in. The solution is filtered when cold and the formalin is then added. It has recently been pointed out to me that 10 per cent. is an unnecessarily large proportion of this agent. It has been found that this strength prevents staining of the chromatic granules of the protoplasm of the nerve-cells, and that much weaker solutions harden quite satisfactorily. Probably, therefore, only about 2 per cent. of formalin should be used. Harden the tissues in this chrome-copper fluid for ten days or longer. Prolonged action of the re-agent does not render them

* From the *British Medical Journal.*

brittle. Wash the pieces for some hours in water after removing from the hardening solution for examination. Cut sections either by the celloidin or gum-freezing method. The latter is in most cases quite sufficient for brain tissue. The sections may be preserved in alcohol in the ordinary way.

The following is the proceeding that I have found most satisfactory in carrying out Heller's process on these tissues :—Place the sections in 1 per cent. osmic acid for half-an-hour (in the dark), then in 5 per cent. pyrogallic acid for half-an-hour, $\frac{1}{4}$ per cent. potassium permanganate for three or four minutes (brain sections for not more than one minute), 1 per cent. oxalic acid for three to five minutes. Wash the sections in water after treatment with each solution. Dehydrate, clear, and mount in balsam.

I have now applied this modification of Heller's process extensively to healthy and morbid nervous tissues, and I am satisfied that it presents great advantages as a method for demonstrating medullated fibres. The staining result is probably as distinct as that furnished by the Weigert-Pal method, and it can be obtained in a much shorter time. The whole process can be carried out within a fortnight from the time the tissues are placed in the hardening solution. The preparations are admirably adapted for lantern demonstration and for photography, and they are suitable for high- as well as low-power microscopic examination. They show degenerating fibres very distinctly, while tracts in which the myelin has wholly disappeared are colourless. The method gives excellent results with the delicate medullated fibres of the brain, and on this account I believe, indeed, that it furnishes what has for long been a great desideratum, especially for the study of the morbid changes occurring in this tissue-element in insanity. The sections may be satisfactorily counterstained in various ways, hæmatoxylin especially giving good results. The nerve-cells are beautifully preserved and stain fairly well. As yet, however, I have not been able to obtain satisfactory staining of the chromatic granules of the protoplasm. It seems probable that the circumstance is due, as indicated above, to the strength of the formalin in the hardening solution, and that, if this was reduced to about 2 per cent., these granules could be readily coloured by the stains generally employed for the purpose.

Life History of a Fern.

By (the late) J. W. Fisher.

IN commencing the study of any branch of natural science, we are confronted with two difficulties which must be overcome if the student would make any progress; these are, technical phraseology and classification. The tendency of the present day is, perhaps, to give undue prominence to the one and almost to obliterate the other. A moment's consideration, however, will show that both are necessary, in due proportion, to a clear and intelligent comprehension of the several facts which form the subject of investigation.

Without an appropriate nomenclature, the definition of form, structure, and properties would become a matter of insuperable difficulty, and involve the use of so many words and phrases that it would be almost impossible to follow the complicated sentences which would be thus rendered necessary. Hence, every branch of science has its own special technicalities, which, however useful and indeed necessary to the student, are often peculiarly perplexing to the non-scientific reader; while, if the practice is carried to excess, as in some modern text-books, the memory becomes burdened with hard words rather than stored with useful facts. Bearing in mind that the present paper is not intended as a strictly scientific treatise, but rather as a popular digest of the interesting phenomena presented in the life-history of a Fern, an attempt will be made to dispense, as far as possible, with technical phraseology wherever simpler language may be made available for the intelligent exposition of the facts presented to the mind.

Equally necessary is a system of classification which will enable us to concentrate our field of view, arrange our facts, and localise the phenomena under consideration. We are all familiar with the general classification of material objects into Animal, Vegetable, and Mineral. Even in this broad generalisation, however, we must not expect to find a distinct line marking the differentiation of these great classes, for although there may be little difficulty in defining a horse as an animal, a cabbage as a vegetable, and a piece of rock as a mineral, there are border-

lands connecting rather than separating these clases, in which it is exceedingly difficult even for the scientist to say with certainty to which class the object under examination may belong.

Confining ourselves now, however, to the great division of Vegetables—to which Ferns undoubtedly belong—we may fairly ask what position in that class they occupy, for its range is so extensive that it embraces every form of vegetable life from the simple unicellular alga, which appears as a green slime upon the surface of a stagnant pool, or the powdery mould on some damp substance, to the most perfect flower which finds a home on the table of royalty, or the gigantic monarch of the forest which for centuries has upreared its leafy head and outstretched its mighty arms, a monument of strength and beauty. We may, therefore, look for a moment at the classification now generally adopted, as it may assist us in comprehending the several successive steps by which we rise from the most simple to the most complex forms of vegetable life.

OUTLINES OF CLASSIFICATION.

I.—THALLOPHYTES.—Algæ, Fungi, Lichens.—The vegetative body, usually a thallus—*i.e.*, it exhibits no differentiation into stem, leaf, and root.

II.—MUSCINÆ.—Liverworts, Mosses.—Sharply defined alternation of generation.

III.—VASCULAR CRYPTOGAMS.—Ferns: *Equisetaceæ*, *Ophioglosseæ*, *Rhizocarpeæ*, *Lycopodiaceæ*, *Selaginelleæ*, *Isoëteæ*. Life-history divided into two generations, extremely different, both morphologically and physiologically. From the spore proceeds a sexual generation—*i.e.*, a prothallium bearing anteridia and archegonia. From the fertilised archegonia proceeds a plant without sexual organs, but in their place a number of spores.

IV.—PHANEROGAMS.—Gymnosperms (naked seeds), Coniferæ, etc. Angiosperms (seeds in an ovary), Monocotyledons, Dicotyledons.

It will now be seen that Ferns occupy an almost central position in the scale, midway between the elementary unicellular algæ, which are scarcely more than a simple mass of protoplasm,

and the highest forms of dicotyledonous plants, where the differentiation of cells is most strongly developed.

Perhaps there are no forms of plant-life more generally admired than Ferns, alike for their graceful forms, variety of outline, and cheerful colour. The various orders of flowering plants each have their admirers, and popular fancy occasionally runs wild in the pursuit of new varieties and rare forms. Tulips, auriculas, roses, chrysanthemums, and orchids present examples of this partiality for the costly and rare in the world of flowers. But Ferns claim the admiration of all classes, and while the wealthy delight in the cultivation of varieties introduced from tropical climes, the humble cottager can enjoy the not less beautiful forms which luxuriate in the hedgerow or dip their graceful fronds in the murmuring stream which runs past the village green.

While, however, in these temperate regions the Ferns are comparatively small and in some instances almost microscopic, in tropical countries they grow to much larger dimensions and even assume the proportions of lofty trees. It is impossible, however, to form any conception of the marvellous size and luxuriant growth to which the Ferns of a far past era in the world's history must have attained, when, in company with gigantic Equisetums, they flourished in the hot, steamy exhalations from the slowly cooling earth, beneath a mantle of murky clouds which scarce permitted the straggling rays of light to render visible the weird forms of the denizens of the carboniferous era. The almost inexhaustible measures of coal underlying the crust of the earth, however, bear witness to the rank luxuriance and vast extent of those primeval forests which the foot of man has never trodden. The Fern, therefore, can boast an antiquity far beyond the genealogy of the more highly developed flowering plants of our day.

Before considering the characteristics which are peculiar to Fern life, it may be well to remind ourselves of the conditions common to all vegetable structures. The substance of all plants is composed of small bodies usually so minute as to be indistinguishable to the unassisted eye, which are termed *cells*. Each of these is capable, at least for a time, of an independent existence complete in itself, and is composed of solid, semi-fluid, and fluid parts, differing in their chemical properties. Usually large numbers

of cells are found in close contact and intimately united, and they there form cellular tissue. But in the life-history of every plant there is one period when certain of these cells become isolated and commence an independent existence as pollen-grains, spores, gemmules, etc.

We may commence our review of the life-history of a Fern at this period of independent cell-existence—that is, with a spore, in which condition each separate individual is complete in itself, and possesses all the potentialities of the perfected plant.

Taking a mature leaf of Fern, we shall find upon the underside a number of bodies differing in form and arrangement in different species. These are the cases, or sori, in which the spores are formed, and by which they are covered until they are fully developed. In the Polypody they are distinct, round, yellow spots; in the Male Fern, they are brown, smaller, and more numerous; in the Hart's tongue they assume the form of elongated rows; while in the Bracken the edges of the leaf are rolled back to form the covering. If a leaf bearing these sori is laid back downwards on a piece of paper, in a few days a quantity of exceedingly fine powder will be found to have escaped from the spore-cases. This is the fabled "Fern seed," whose mysterious power of rendering its possessor invisible has formed the subject of many an old-world legend. This powder, however, does not consist of seeds, but spores, and there is a wide distinction between the two which we may for a moment profitably consider.

Seeds are defined as "independent reproductive bodies, containing an embryo or rudimentary plant at the time when they are cast off by the parent." Take any ordinary seed (a pea or bean may be selected because of their size and familiarity), and carefully divide it through the centre so as to disclose the interior, and it will be found to consist of three parts:—first, the outer skin or shell; within this a quantity of albuminous matter (which, however, is not present in all seeds); and embedded in this fleshy substance a small body, usually curled more or less into a semicircular form, which is the embryo or rudimentary plant. When germination commences, the embryo throws out a tiny rootlet, which grows downwards, and an upright stem with leaves pushes itself upwards through the soil. Here in the embryo we have all

the parts of the perfect plant ; and the production of roots, stem, leaves, flowers, reproductive organs, and seed like to that from which it sprung, is but a continuation of growth commenced in the germination of the initial seed. There is thus from seed to seed the perfect cycle of a life-history in one generation.

The genesis of a spore is, however, essentially different. Here, in the cycle of its life-history, we find two generations, sexual and non-sexual in alternation, before we return to the point from which we started with the spore. Moreover, the character of a spore is quite distinct from that of a seed, inasmuch as it possesses neither albumen nor embryo, and in its constitution approaches more nearly to the pollen-grain, although widely differing from it in its functions.

The spore is an isolated cell, consisting of three parts. First, an outer skin, somewhat irregular in its form and brittle, but destitute of the pores found in the extine of the pollen-grain. Secondly, an inner integument exceedingly thin and elastic, which encloses a fluid mass of protoplasm. Under favourable conditions of warmth and moisture, germination commences by the outer skin being ruptured and the inner skin becoming extruded, while a vegetative process is set up in the contained protoplasm, minute granules of chlorophyll are developed, and the young cell becomes self-supporting, being capable of assimilation. Sub-division into two cells is effected by the formation of a transverse septum. The outer cell is again sub-divided, and there are now three cells placed end to end, and still retained in contact with the ruptured spore. The third cell is similarly divided, and now, in addition to the transverse septum, another wall is formed at right angles to the former, separating the cell into four parts. The growth thus proceeds by repeated transverse and longitudinal bipartition, until a somewhat heart-shaped, flattened expansion of cells is the ultimate structural result. This is called the prothallium.

On the under side of the prothallium, by the unequal growth of the cell-walls, long, unicellular root-hairs are formed by which water and soluble earth-salts are absorbed. A further development now ensues, and the reproductive organs are formed upon the same side—viz., the antheridia, or male organs, on the lower part, and the archegonia, or female organs, on the upper part of the prothallium.

The archegonium is a multicellular body, possessing a central canal, terminating in a circular cavity containing the germ-cell, from which, after fertilisation, will spring the future plant.

The antheridium is a closed sac, within which are enclosed the mother-cells of the antherozoids, and from which they are expelled after arriving at maturity by the rupture of the outer cell-wall. The antherozoids thus set free are minute bodies possessing the power of locomotion by means of the rapid motion of the vibratile cilia with which they are furnished; and they are thus brought into contact with and fertilise the germ-cell of the archegonium. In these strange bodies we approach curiously near to some of the lower forms of the Infusoria, and find ourselves in the mysterious border-land where animal and vegetable commingle with scarcely a perceptible dividing line.

After fertilisation, the germ-cell undergoes further changes by division and sub-division, the resultant cells becoming differentiated, and each by independent vegetative processes developing the various parts of the mature plant: root, stem, rachis, frond, and spores. The young plant, when first formed, remains in contact with the prothallium, from which it derives its principal nourishment. After a time, however, the prothallium gradually withers away, and the young Fern commences its independent existence.

Taking them in this order, we commence with the roots, which are usually fine fibrous hairs, especially fitted for effecting an entrance into and between the several interstices in the old walls, rocky caverns, or stony hedge-banks, where so many of the Ferns delight to luxuriate.

The stems of Ferns are for the most part underground or creeping upon the surface. Where they are ascending they do not attain to any size in this country; but in the Tree Ferns of tropical lands they grow to the dimensions of forest-trees. But whether creeping or ascending they all partake of a similar character, and consist internally of a central pith, outside of which is a loose mass of cells enclosing a number of isolated vascular bundles, and surrounded by a continuous network of vascular tissue with large meshes, each mesh opposite to the point of insertion of one of the leaves, the vascular bundles of each leaf being given off from the

margins of the meshes. The external surface of the stem is thickly covered with the persistent bases of the leaves, and these are densely clothed with brown scaly hairs or ramentæ.

The leaves of Ferns are much slower in their development than those of other plants, for an examination of the stem reveals the fact that two years are occupied in their growth before they appear as mature leaves. Thus, the stem not only bears the persistent bases of older leaves that have died down in former years; but three generations of growing leaves, one of which is the perfect leaf of the present season, and the others are buds in different stages of development which will arrive at maturity in succession during the ensuing two years.

Not only in the duration of their growth, but in the manner of their development, the leaves of Ferns differ materially from other orders. A familiar example of this peculiarity may be seen in the young leaves of the Hart's-tongue Fern, which, when first they appear in the spring above the surface of the soil, are beautifully curled up from the tip, like a beautifully-formed crozier, and as the growth advances they are gradually unfolded until the leaf becomes fully expanded. This curling-up of the young leaf, which is termed circinate vernation, is characteristic of all ferns, and in some of the pinnate species assumes very complicated and beautiful forms. Ruskin's definition of a leaf is peculiarly applicable to these delicate and lovely unfoldings of the young Ferns. He says it is "the thing that is born" or "put forth." "When the branch is tender and putteth forth her leaves, ye know that summer is nigh." "It is the springing thing," this thin film of life; rising with its edge out of the ground—infinitely feeble, infinitely fair.

It will be observed that throughout we have spoken of leaves rather than fronds, which is their general designation. But modern botanists are of opinion that no material object can be served by the retention of the popular word "frond," inasmuch as they are, equally with the leaves of higher orders of plants, organs of respiration and assimilation, wherein by a vital action those liquid and mineral constituents derived from the soil by the roots, undergo the chemical changes which are needed to fit them for the vegetative processes of the plant.

It is unnecessary to enter into an examination of the many

forms and varieties of Fern-leaves, as that would take us far beyond the limits of the present paper, and though interesting from their varied forms of beauty, and important as characteristics for the classification and determination of genera and species, really form no part of the life-history of a Fern.

We are rather concerned now to note the mode of fructification in Ferns, in which we find another wide divergence from the plan which prevails in the several orders of Phanerogams, since there is an entire absence of flowers and fruits in the ordinary acceptation of the terms; hence, they are included in the extensive order of Cryptogams or flowerless plants.

Taking a single pinnule from the leaf of the Maiden-hair Fern for our illustration, we notice that the veins, which are distinctly visible on the under-side, proceed from the mid-rib and become bifurcated, a mode of division universally prevailing in Ferns. On these veins are situated groups of Spore-cases, which are called Sporangia. They consist of a slender stalk connecting them with the substance of the leaf, and bearing a lens-shaped sac surrounded by a ring or annulus of thickened cells, which are highly hygrometric in their character. These sporangia in many species are covered with a thin film of cellular tissue called the Indusium, affording a protection to the sporangia until they are matured. These groups of sporangia are known as Sori, and their different character, shape, and position are distinguishing marks in the identification of species. In the majority of ferns they are distinct round or kidney-shaped spots, but sometimes so closely situated that they become confluent, and appear to cover the entire back of the leaf, and the Hart's Tongue and Bracken have already been mentioned as departures from this general form.

Within the cavity formed by the convex sides of the sporangia the spores are produced by the division and sub-division of a mother-cell. When these are fully matured, the indusium becomes loosened around its margin; the annulus or ring surrounding the sporangium is deprived of its enclosed moisture by evaporation; and by a sudden movement, tending to straighten itself, it breaks asunder, rupturing the thin side-walls, and scattering the contained spores with considerable force, each with an independent existence to commence another cycle of life-work. There are many varia-

tions from this typical example; but in all there is uniformity of principle, and in all species of Ferns the cycle of their life-history is the same, and the successive stages are similar.

First, an independent and isolated spore, which germinates, producing a prothallium bearing sexual organs. From these arise in the second generation a perfect plant, possessing root, stem, and leaves, non-sexual in its nature, but completing the cycle by the formation of a fresh generation of spores.

Thus, through all the ages, these living organisms have run their course in never-ending cycles of life-history, all united by a common brotherhood, each to each, yet each distinct and separate, each one after its kind. Surely, by no fortuitous chance have these various cells become differentiated to serve their purpose in the economy of the living plant, but in obedience to a Divine law, which had its first utterance when the Almighty Creator called them into being, and gave them their mission in the world which He had formed. Happy the eyes which can recognise the evidences of unerring Wisdom in these beauteous forms of life, and in the contemplation of their wonders "rise from Nature up to Nature's God."

Colour Experiments with Plants.—So far, those gentlemen who have conducted experiments with fruits and flowers for the production of diverse colouration do not seem to have met with much encouragement. It seems as if Nature's wonderful ways in creating so many varied and beautiful hues were secrets which science has not yet succeeded in penetrating. All the same, there can be no harm if experiments in other directions be continued, especially in relation to apples, because we have assured, though to me always a matter of doubt, that certain mineral applications to the roots would produce high colour. The most interesting of flowering plants to operate upon seems to be the Hydrangea. I noticed in the summer plants of *H. hortensia* blooming in pots in the conservatory at Basing Park, both pink and blue, and Mr. Smythe assured me that the blue tint was produced by occasional waterings with dissolved alum. Is that really so?—"A. D.," in *Journal of Horticulture.*

Common Freshwater Shells.

THE subject I have chosen for this paper is, I am afraid, not a popular one. Firstly, because Conchology is not a popular science; and secondly, because the title "Common Freshwater Shells" does not sound very fascinating. The fact that shell-collecting is not nearly so largely indulged in as butterfly collecting or birds'-egg collecting, is very largely due to the want of cheap popular books on the subject. If a person unversed in conchology could read in simple language some information about the shells he happened to find, he would become interested, go further afield, and in time get to understand the standard works of the day. But when the beginner finds that "the mantle margins" of the animal he has found "are slightly cerrated in the branchial region, and united posteriorly by the branchial septum," his natural conchological tendencies get nipped in the bud. Probably, also, many people never get over their inherent dislike for slimy snails and slugs, even though they handle a beetle with the utmost unconcern. But be these things as they may, Conchology ought certainly to take a much higher place among the "popular" branches of Natural History than it does. Land and Freshwater shells need only the simplest of tackle for their capture; they are far easier to prepare for the cabinet than insects, for there is no tedious and sight-trying "setting"; they do not require the repeated attention which flowers do when going through the process of drying; and, lastly, they are not liable to be totally destroyed by mites when they finally find their resting-place in the cabinet. Many of the marine shells, it is true, require a dredge for their capture, but very many may be taken without. By the seaside, by riverside and lakeside, by ponds and streams, in meadows, marshes, gardens, and waste places, "Far from the madding crowd's ignoble strife," the delightful hobby may be fully indulged in, and the despised snails caused to render a rich harvest of lovely shells and fascinating information. In spite of all the learning of the Nineteenth Century, there are more things in snails and slugs "than are dreamt of in our philosophy."

The average person knows less about snails than he does about almost any other branch of natural history, and this is saying a

great deal. For even if his scientific research is of so high an order that he knows a rook from a starling and a blackbird from a bullfinch, that he has ceased to regard a bat as a bird, and a whale as a fish, he still probably classes land-snails as insects and sea-snails (best known to him in the form of oysters, cockles, whelks, etc.) as fishes. Many people—perhaps most people—do not know that there are such things as Freshwater shells, and as these are so easily to be found, and some species are so very abundant, this is rather to be wondered at.

The great abundance of any one species admits of one particularly interesting study—namely, the noting of the different varieties to which that species is subject. If, for example, there is an abundance of food, we get fine, large shells ; if, on the other hand, food is scarce, we get stunted shells. Heat, again, in one species at any rate, produces thin shells ; absence of lime gives us decollated shells. This is very well illustrated by that extremely common freshwater shell, *Limnæa peregra.* Some shells of this species are small, very delicate, and almost without colour, whilst others are thick, heavy, large, and dark ; some are very broad, others very narrow ; some glossy and others dull ; and one variety, known as "*burnetti*," has no spire.

This is a gregarious species, the animals being found together in very large numbers, and as the animal is extremely prolific this is to be expected. It inhabits rivers, streams, ditches, ponds, and lakes, and is found in every part of Great Britain. It is an active animal, often leaving the water to climb upon the stems and leaves of surrounding plants or crawl about on the mud, thus earning its specific name—*peregra*, "wandering." It frequently wanders to some distance from its usual home, and when in captivity is given to leaving the vessel in which it is supposed to be confined. Although, as a rule, it is a vegetable feeder, it has been known to attack and kill fish when kept in the same aquarium, and also to eat the dead bodies of members of its own species. It has even been known, when pressed by hunger, to attack and eat its own fellows. On the other hand, it is the prey of birds and fishes ; also leaches, and parasites known as Gordias.

A distinguished conchological member of this Society* says

* The Leeds' Naturalists' Club and Scientific Association.

that it has been generally accepted that the narrower forms inhabit streams, when less resistance is offered to the running water than would be the case with the more globular forms; hence, the latter inhabit ponds where there is no motion in the water. But his experience does not bear this out, some of the most elongated forms in his extensive collection having been taken from ponds. Certainly, some specimens which I have taken from the Wharfe at Poole last summer are distinctly globular.

The eggs of this interesting mollusc are round and colourless, with a whitish opaque spot at one end, and as many as eighty eggs, or even more, are to be found in one mass of the protoplasmic substance in which they are enveloped. This spot is the embryo of the future snail and grows day by day, and may be seen moving in the egg before hatching. A single individual has been known to lay as many as one thousand three hundred eggs during one season. "Most of the full-grown animals," says the authority previously quoted, "that deposit their eggs in early summer at once die off."

Closely related to, but not nearly so common as, *Limnæa peregra*, is *L. stagnalis*, one of the most graceful, and perhaps *the* most graceful of our freshwater shells. It inhabits sluggish streams throughout the country. It is a lazy species, and adheres very firmly to the object to which it has attached itself. Another habit is that of floating on the surface of the water. This species differs from the last in its choice of food, *Limnæa peregra* preferring vegetable matter, whilst *L. stagnalis* lives principally on animal matter.

We will now take a glance at a member of an entirely different family. *Viviparus viviparus* is interesting because its eggs, instead of being left in the water to hatch—as are those of the two preceding species—are kept within the shell of the parent, and when these are hatched the young still remain there for two months at least. They have then become capable of finding their own nutriment. When they have reached this stage, they do not all leave the parental shell together, but straggle deliberately out three or four at a time at intervals of several days. The mouth of *Viviparus viviparus* is protected by a horny operculum or "lid." The species is said to be plentiful in the South of England.

Let us now turn our attention to two species of our freshwater bivalve shells. Perhaps the best known of this class is that extremely common, very prolific, and remarkably variable shell, the common River Mussel, known as *Anodonta cygnæa.* There can be no wonder that this species is common when it is considered that a single individual has been estimated to produce three hundred thousand young in one season. And it is no less a wonder that it is so variable when, owing to its large numbers, it lives under so many different conditions.

It is found in rivers, canals, lakes, ponds, etc. This species is easily kept in an aquarium, and when kept thus in captivity can easily be made to demonstrate the interesting manner in which these creatures breathe. If a very small quantity of carmine or other suitable colouring matter be placed gently near the anodon, the existence of two currents will be at once perceptible, one current going to and the other from the animal. This is because, in order to supply the animal with the necessary amount of oxygen, the gills are kept continually bathed with water, which, entering by one tube or "siphon," leaves the animal by another alongside the first, the oxygen having been duly extracted from the water. Some of these shells attain really large dimensions, measuring as much as nine inches.

From a utilitarian point of view, the anodon is not of much value, although I have heard it said that fresh-water mussels are eaten by some people. This, however, may not refer to the species in question. The practice is certainly not a fanciable one, and, one would think, not very conducive to health.

Pearls are occasionally found in these Swan mussels, and are generally either a green or rose colour. The once-famous Pearl mussel of this nation, however, belongs to another genus, all the British members of which produce pearls. This is *Unio margaritifer.* It is found among the gravel and small stones of quick-running rivers or mountain torrents. It has also been known to occur in several parts of a canal, where, however, the bottom is gravelly. In this case the animal has been carried in by the water-courses which supply the canal. This mollusc is, or was, used in the Aberdeen fishery as bait.

The Scottish Pearl Fishery continued till the end of the last

century, especially in the river Tay, where the peasants collected them before harvest time. The pearls were usually found in old and deformed specimens. Round pearls, perfect in every respect, about the size of a pea, were worth from three to four pounds.

In the Irish Pearl Fishery the mussels are said to have been found "set up in the sand of the river beds with their open side turned from the torrent." About one mussel "in a hundred might contain a pearl, and one pearl in a hundred might be tolerably clear." So that one mussel in every ten thousand which were opened might contain a tolerably clear pearl. At one time the pearl fisheries in this country were a source of considerable revenue to their owners. It is stated in Brown's *Recent Conchology* that the pearls sent from the river Tay, in Perthshire, to London from the year 1761 to 1764 were worth £10,000. Tradition is silent as to how many mussels were killed in this search for pearls, but the number must have attained collosal dimensions.

It may be mentioned in passing that *Unio margaritifer* is mythologically supposed to have furnished pearls for the British crown. One pearl furnished by this mussel, seen by Sir R. Redding (who lived in the seventeenth century) was purchased for £30 by the owner, who had previously refused nearly three times that sum for it.

British pearls, by the way, have played a part in Classic History. It is mentioned by Pliny that Julius Cæsar obtained in Britain a sufficient number of pearls to cover a breastplate, which he dedicated to Venus and hung in her temple. It is evident from Pliny's account that the pearls were small and comparatively valueless, and so Cæsar's piety has been treated with incredulity, and the suggestion offered that he only presented the pearls to the goddess because the Roman ladies would not have worn them. These pearls may have been produced by *Unio margaritifer* or by the common edible mussel.

Pliny also furnishes us with another classical piece of conchology, the truth of which is not borne out by modern investigations. Here, however, he is apparently not speaking of freshwater shells. He tells us that the divers had to practice considerable skill, for the oyster snapped at the diver's fingers and lopped them off if he were not quick enough in his motions.

While we are on this subject, the remarks of Tacitus on British pearls might be noticed. He says:—"The ocean also yields pearls, but they are cloudy and discoloured. Some believe that the gatherers are deficient in skill, because in the Red Sea they are torn alive and breathing from the rocks; while in Britain they are merely collected as they are cast ashore; but I should rather suppose that the quality of the pearls is inferior, than that we are deficient in avarice."

It is well known that pearls are produced by some foreign matter becoming lodged in the shell in such a way as to annoy the occupant, and cause it to coat that matter over with a nacreous substance in order to make it smooth and less painful. The Chinese take advantage of this practice, and introduce into the shells of mussels 'josses' and other articles in order to obtain a coating of pearl.

Sand was generally said to be the nucleus of pearls, "but this is simply a conjecture which has gradually become regarded as a fact. It is quite the exception for sand to be the nucleus; as a general rule, it is some organic substance." The most generally prevalent nuclei appear to be the bodies or eggs of minute internal parasites. The prevailing colour of the pearls of *Unio margaritifer* is white; but green, brown, black, and flesh-coloured or pink pearls are occasionally found, those of the last-mentioned colour, when large and well shaped, being of considerable value.

The shell of this species of mussel is very thick and heavy. It is about five and a-half inches long, and is covered with a strong, dark-coloured, or in some cases black, epidermis. The interior of the shell is very thickly coated with mother-of-pearl.

EXTINCT PLANTS.—The number of species of plants which have become extinct is very large, and yet generic groups rarely die out. Comparative researches show that much the greater proportion of plants whose remains have been preserved in a fossil condition from earlier geologic periods belong to the genera which are represented by plants now living, although many of these existing plants differ specifically from the earlier ones. From this it seems that new types are outgrowing the old ones constantly, and take their place in the general scheme of life.—*Journal of Horticulture.*

The Formation of Dew.

THE following observations by Dr. J. G. McPherson, F.R.S.E., Lecturer on Meteorology in the University of St. Andrew's, are cited from the *Wakefield Express*:—

"Until very recently the exact constitution of the nature and formation of dew was unknown even by scientific men. The opinion was generally held that if you sped through the glistening meadow on a summer evening, through the diamond drops sparkling in millions, you would get your boots or trousers moistened with dew. It was also believed that dew fell from the air upon the ground. Now in both cases the opinion is wrong, for it is not dew at all which was encountered in the meadow, and dew does not fall from the air. If you look into the garden on a dewy night—for there is such a thing as dew for all that—you will find some plants moist. Glistening drops appear on the broccoli, but the peas are dry. Place a hand-lantern below one of the healthiest broccoli leaves, and you will find that the moisture is collected in clear drops along the edge of the leaf and at the end of the veins of the leaf. The leaf veins radiating from the centre line of the surface have carried the moisture of the healthy plant to the edges to keep up plant circulation; and the drops you see are not dew-drops, but the watery juices carried out by the energy of the healthy plant. For, place the lantern under an unhealthy leaf and you will find no drops; there is no circulating vitality in it. Again, examine grass blades, and you will find large drops near the tips of the blades, the rest of the blades being quite dry. The large drops seen on plants at night are falsely called dew; they are produced from the plants themselves as tokens of their active and healthy growth.

This can be demonstrated in more than one way. Remove a branch of poppy, and connect it by means of an indiarubber tube with a head of water of about forty inches. After placing a glass receiver over it to prevent evaporation, leave it for three hours. Then you will find water has been freely excreted through the veins, resembling what were familiarly called 'dew-drops.' If the water pressed into the leaf is coloured with aniline blue, the drops when they first appear are colourless, but before they grow to any

size the blue appears, showing that little water was held in the veins. What, then, has been for centuries called dew is not dew at all, but the watery juices of the healthy plants.

But look over dead leaves on a dewy night, and you will see a fine pearly lustre—that is dew. Dead matter gets equally wet when equally exposed, and real dew is not so common as is generally supposed. On many nights on which grass gets wet no true dew is deposited on it, and on all nights, when growth is healthy, the exuded drops always appear before the true dew. The difference between the true and the false dew can easily be detected. The moisture exuded from the leaf veins of the grass —false dew—is always isolated at points situated near the tips of the blades, forming drops of some size; whereas true dew collects evenly all over the blades. A glance distinguishes the pearly lustre of the dewy film from the glistening diamond drops of the healthy plant's juices.

But whence comes the dew? It does not fall from the air. Whence comes it then? We shall see. Ground a little below the surface is always warmer than the air over it. So long, then, as the surface of the ground is above the dew point, vapour must rise and pass from the land into the air. The moist air so formed will mingle with the air above it, and its moisture will be condensed, forming dew wherever it comes into contact with a surface cooled below the dew point. In fact, dew rises from the ground.

Place some metal trays over the grass, the soil, and the road on dewy nights. You will generally find more moisture on the grass inside the trays than outside; you will always observe a deposit of dew inside the trays, even when there is none outside at all. This shows that far more vapour rises out of the ground during the night than condenses as dew on the grass and the objects.

Pieces of iron lying on grass are soon surrounded by richer grass, on account of the moisture which the cold metal attracts from the rising water-vapour. Travellers in Australia and South Africa state that they often found the under-side of their waterproof bedding placed on the ground to be wet after camping out at night. That shows that even in dry countries vapour rises from the ground at night. I remember, when walking in the vicinity of

Hexham with an acute observer, trained to farming, that, on my remarking that the farmers might to their profit remove the extraordinary quantity of small stones from the fields in order to give room for the growth of the grain, he shrewdly said, 'These stones collect moisture from the ground ; the soil is thin, with a gravelly subsoil, and unless the maximum amount of moisture is collected (which can only be done by allowing these stones to remain), there would be a very deficient crop. They must not, therefore, be removed.'

Dew, then, rises from the ground. But how is the dew formed on bodies high up in the air ? If the dew comes out of the ground, should it not be found on bodies only exposed to the earth ? Now, dew does not rise in particles, as it was once considered to fall in particles like fine rain. It rises in vapour. Some is caught by what is on the surface of the earth, but the rest ascends in vapour form until it comes in contact with a much colder surface, to condense it into moisture. The vapour does not flow upwards in a uniform stream, but is mixed in the air by eddies and wind currents, and carried to bodies far from where it rose. In fact, dew may be deposited, even though the country for many miles all round is dry and incapable of yielding any vapour. In such cases the supply of vapour to form that dew would depend on the evaporation of the dew, and on what was wafted over by the winds.

But the most practically convincing proof of the rising of dew from the ground is in the form of hoar frost or frozen dew. If it has been a bright, clear, sunny day in January, with no snow on the ground, look over the garden, grass, and walks on the morning after the intense cold of the night ; big leaves may be found scattered over the place. You see little or no hoar frost on the upper surface of the leaves, but turn up the surface next the earth, or the road, or the grass, and what will you see ? You have only to handle the leaf in this way to be highly astonished. A thick, white coating of hoar frost, as thick as a layer of snow, is on the under surface. Leaf after leaf will present the same appearance. If a number of leaves have been overlapping each other, then there will be no coating of hoar frost under the top leaves ; but when you reach the lowest layer, next the bare ground, you will

find the hoar frost on the under surface of the leaves. Now, that is positive proof that the hoar frost has not fallen from the air, but has risen from the earth. And hoar frost is frozen dew.

Dew, then, mostly rises from the ground, and what used to be thought dew is the active exudation of the healthy grass. These two facts are now established. Brilliant globules are produced by the vital action of the plant, showing life in one of the most charming forms in the phenomena of Nature."—*Journal of Horticulture.*

Cutting and Mounting Sections of Cereal Grains and Starchy Tubers.*

By J. D. Hyatt. Plate XIV.

THE reason for the present exposition is not the claim to the discovery of anything new in the methods adopted, but the remembrance of the difficulties which I have lately encountered, together with a consideration of the fact that, during my twenty years' membership in this Society, the American Microscopical Society, and the American Microscopical Postal Club, I have never yet seen, on exhibition, a section of wheat or other grain. While we have had before us sections of almost all conceivable organic and inorganic substances, it seems a little remarkable that a microscopical study of such great economic importance as that of the cereal grains should have been omitted. It is true that we find drawings and descriptions of such sections in our botanical works and agricultural reports, but we all know how such descriptions compare in interest with a view of the objects themselves.

My principal motive, however, in presenting these sections to you this evening is to illustrate the educational value of the microscope in our public schools. Dr. Julien, in his interesting and admirable address before this Society on "Microscopy in the Scheme of Education," has advocated in very forcible terms the value of the microscope in arresting the attention, and developing

* From the *Journal of the New York Microscopical Society.*

the observing and reflecting faculties of children. While I have seen the time when it might have been considered an unwarrantable innovation and encroachment upon the exclusive domain of "the three R's" for a teacher, in one of the New York public schools, to bring a microscope into the class-room; yet, under the more intelligent administration of our present School Board, such a step may now not only be taken with impunity, but possibly be even regarded with favour.

In some of the schools in this city there has been established within the last few years a course of instruction in manual training, in which the boys, under teachers especially qualified, are instructed in designing and working various simple devices in wood, and the girls are taught sewing and cooking. In the last art it is wisely provided that the teacher shall not simply be a cook, but a person thoroughly skilled in such scientific and technical knowledge as may enable her to give intelligent instruction regarding the nature and nutritive value of the various articles used for food. She is also required, in the language of the school manual, to explain and make clear to the minds of her young students in cookery such (to them) abstruse subjects as the "Germ Theory, and the Causes of Decay and Decomposition in Organic Bodies."

By what process of instruction the teachers were expected to develop in the minds of pupils, from twelve to fourteen years of age, clear ideas of these subjects without the use of the microscope is quite incomprehensible. Such an instrument as the microscope has never been on the list of school supplies. Possibly it was supposed that these very young people could attain this scientific knowledge by the same process of intellectual development that has, in times gone by, been pursued in regard to all other subjects taught, and that is, by committing to memory the explanations to be found in properly prepared text-books.

An additional motive for presenting this subject is an occurrence in my own late experience. Happening to visit the cooking teacher's class in my school one day, I found her engaged in explaining to the pupils the relative nutritive value of the various kinds of flour, dependent upon different processes in milling the wheat. While the teacher's explanation was sufficiently lucid, the difficulty of fully conveying her meaning to the minds of these

young girls will be easily understood when we reflect that, probably, not one in ten of our city girls has ever seen a kernel of wheat, or has the remotest conception how or of what flour is made. In this instance, while the pupils were outwardly exhibiting respectful attention, there was still an air of listlessness which indicated the wandering thought. The teacher quickly perceived this, and, interrupting her lecture, asked if I could furnish a section of the kernel of wheat, which, when placed under the microscope, might facilitate a proper understanding of the subject.

I agreed to furnish the section. But I discovered later that it is sometimes much easier to promise than to perform. I found no difficulty in cutting the section. But, after four or five days' trial, I learned that to mount it properly and permanently was one of the most difficult undertakings I had ever attempted in all my thirty years' experience in preparing microscopical objects. The persistent obstinacy with which the starch-grains would, under every conceivable method of treatment, leave their cells and flow into the mounting medium, surrounding and beclouding the section, was the obstacle to be overcome.

It is to save a like expenditure of time to such of our members as may wish to prepare similar sections that I exhibit the final results of my labour. The mounts, though not entirely free from a few surrounding starch-grains, are fairly satisfactory, as the slides on the stands will show. I am already more than repaid for all labour, however, by the great interest manifested by the pupils when these sections were examined by them under the microscope, and by the readiness with which they evidently comprehended all subsequent explanations of the "nutritive qualities of flour as developed by different processes of milling." Any child could easily comprehend, upon examining the sections, that flour, deprived of the nitrogenous matter contained in the gluten cells, so beautifully arranged around the white starchy interior, would lose its most nutritious element.

All the pupils were required to draw upon paper a figure of the section as it appeared to them under the microscope. This was fairly well done by nearly all at the first attempt. The only fault being in some cases a disproportionate exaggeration of the coats surrounding the interior starchy cells.

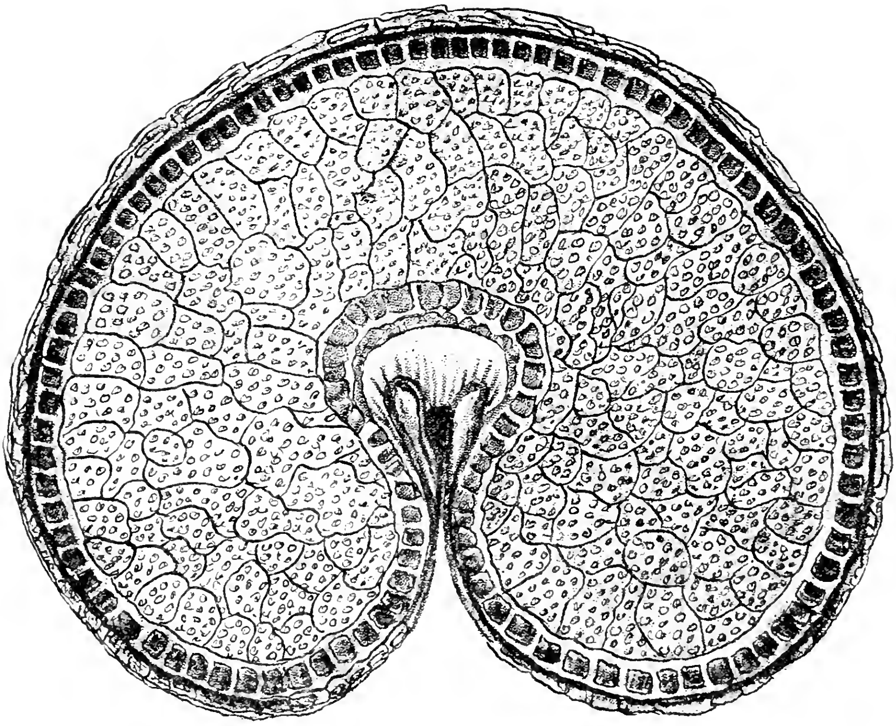
I have here reproduced one of the sections most correctly drawn by them, showing the contents of a kernel of wheat. It represents a transverse section magnified about thirty diameters. The extreme outer coat (Plate XIV., 1) is the epiderm or husk, and constitutes what in milling is called "the bran." It consists largely of cellulose, and contains no important nutritious element. The next layer (2), quite thin, contains some oil and albumen. The rectangular symmetrically arranged layer of cells (3) are filled with gluten. The entire interior (4) is filled with cells of irregular shape containing starch, and it is of this that the finest wheat flour is almost exclusively made. The more nutritious nitrogenous elements contained in the gluten cells are excluded in the milling, because these gluten cells, being of a darker colour, would, if ground with the flour, impair the extreme whiteness, which, in the estimation of bakers and of most housekeepers, constitutes its chief value. Chemical analysis, however, shows that flour milled from the so-called "whole-wheat," including layers 2 and 3, in which reside certain nitrogenous and other mineral elements, makes a bread much more nutritious and wholesome, though of a darker colour, than that made from the fine wheat flour. In sections of wheat, rye, oats, and Indian corn, only a single row of gluten cells is seen. In barley there are three rows, but in this latter case the cells being smaller the quantity of gluten contained is not so greatly in excess, as the number might indicate.

No especial difficulty is encountered, and no especial experience is required, in making satisfactory sections of grains. The main precaution is to soften the kernels slightly, and not too much, by immersion in water. If too soft, the starch will fall out of the cells. If too hard, the sections crumble under the knife. Indian corn may be kept moist for twenty-four hours; wheat four or five hours; rye five or six; barley ten or twelve; and oats not more than one or two hours. The difference in these grains, with regard to the length of time required to soften them, consists in the thickness or hardness of the outer or epidermal coat. This in Indian corn is hard, dry, and oily, and therefore resists the action of water. In oats it is very thin and easily penetrated. Barley, having a very shallow groove, and being surrounded by a thick

coat of gluten cells insoluble in water, resists softening for a long time. Embedding may be done in any convenient manner, as the sections are easily cut when the grain is slightly softened. Perhaps paraffin is the best material for the purpose, as it holds the grain so firmly that it may be cut in any direction. No elaborate microtome is necessary. Any simple section-cutting contrivance answers quite well. But care must be taken to have the knife as sharp as possible. The requisite thickness, or rather thinness, of sections is a matter of some importance. The starch-grains will all fall out if the sections are too thin, and the gluten cells will be disagreeably opaque if they are too thick. But as a great number of sections can be cut from a single grain, a selection can easily be made of such as appear of a proper degree of transparency.

Glycerine jelly is the best medium for mounting. This must be softened to the requisite degree of fluidity by placing it in a cup of warm water. The sections are best removed from the knife by a camel's-hair pencil. If they are deposited in a shallow dish of water, they may be taken up with the pencil as wanted and placed upon the slide, the centre of which should be marked on the back with a dot of ink. If the slide is held inclined, a drop of water placed above the section will run down and carry away nearly all the surrounding grains of starch. If any starch-grains remain, they may be removed with a small brush. Now, while holding the slide in a horizontal position, take a cover in the forceps, warm it slightly over a spirit-lamp, and holding its exact centre over the section, lower it carefully upon the gelatine. If this is carefully done, the cover will settle down to its place without disturbing the starch-cells. Any attempt to move the cover or to press it down will cause a cloud of starch to issue from the cells. Should the gelatine become somewhat hardened before the cover is put on, so that it does not go down of its own weight, allow the gelatine to become quite hard, then place a slight weight on the cover and gently warm the slide over a lamp. The cover then will settle down to its place without disturbing the starch.

The most difficult sections to mount are those of oats and wheat, while little difficulty will be experienced with Indian corn, barley, or rye. Sections of potato and other starchy tubers are easily mounted by following the foregoing directions. All attempts



Section of Grain of Wheat.

F. Phillips Sc.

to fix the starch in its cells by any gum or cement, before or after cutting the sections, proved with me entirely futile.

EXPLANATION OF PLATE XIV.

TRANSVERSE SECTION OF GRAIN OF WHEAT.

1.—Fruit coats : epidermis, mesocarp, and endocarp.

2.—Seed coats.

3.—Gluten cells, or perisperm.

4.—Starch cells, or endosperm.

Animal Cannoneers and Sharp-Shooters.*

BY JAMES WEIR, JUNR.

ALTHOUGH the animals concerning which I wish to write in this paper do not use powder and ball in charging their weapons, they do use materials which, if not so deadly, are yet very efficient missiles. I am inclined to believe that the Chinese borrowed one of their defensive as well as offensive weapons, the stink-pot, from one of the lower animals,—namely, the bombardier beetle.

I well remember that, when a lad, I once experienced the overpowering effects of a Chinese stink-pot which had been brought from China by a missionary. This gentleman, who was a practical joker, ignited this instrument of barbaric warfare and placed it on a table in the hall of the house where I happened to be visiting. In a very few moments the house was emptied of all its inhabitants, who fled, coughing and strangling out into the open air.

I remember distinctly that I likened the effluvia that escaped from this horrible weapon to the odour of the "stink-bug," an insect belonging to a family (*Pentatomidæ*), genera of which exist throughout the entire world.

Professor Comstock pleasantly calls attention to this family of animal bombardiers in the following words: "To those who live

* From *Lippincott's Magazine*.

in cities it may always remain a mystery why one berry, looking just like another, should taste and smell so differently; but all barefooted boys and sunbonneted girls from the country who have picked the wild strawberries on the hill-sides, or scratched their hands and faces in raspberry patches, know well the angular green or brown bugs that leave a loathsome trail behind them; and they will tell you, too, that the bugs themselves are worse than their trail, for it is a lucky youngster that has not taken one of these insects into his mouth by mistake with a handful of berries."

The common brown bombardier, stink-bug, or sour-bug, is an animal of no little intelligence, as any one who has watched its manœuvres when in the presence of an enemy will readily admit. On such an occasion the bombardier reminds one of a man-of-war that is manœuvring for a favourable position when about to engage in a naval combat. It endeavours to keep the side of its body toward the enemy, for its artillery is placed on the lower side of its body, one, two, sometimes three, small weapons on each side. When the enemy has come within range, this astute little warrior elevates the side of its body that is next to its foe, thus bringing its guns to bear, and then fires a broadside of acrid, ill-smelling fluid at its opponent. If its molester still continues its attacks, the bombardier will quickly turn, elevate its other side, and fire its remaining broadside. The stink-bug is commonly victorious at its first volley; but sometimes the enemy is persistent and continues to harass this insect hurler of stink-pots until the creature exhausts all its ammunition. What does it do then? It resorts to a subterfuge that is practised by many other animals, even by man himself: it feigns death. It draws its legs beneath its body, retracts its antennæ, and sinks to the ground, to all appearance as dead as Shakespeare's famous door-nail. Its foe, believing that it is dead, abandons it, for it seems a silly and useless procedure to maltreat and mutilate a dead opponent. The cunning stink-bug, as soon as its enemy departs, comes to life, and in half-an-hour is ready for another combat, so quickly does it acquire another supply of ammunition. The bombardier's cannon are small glands situated on the lower side of the body near the middle legs. These glands secrete an acrid, fœtid fluid, which, by a voluntary effort of the animal, is ejaculated at its enemy.

A South American bombardier takes precedence, however, of all insect cannoneers, inasmuch as its broadsides are accompanied by both sound and smoke. Mr. Westwood, a distinguished English entomologist, quotes Burchell as stating that "while resting for the night on the banks of one of the large South American rivers, he went out with a lantern to make an astronomical observation, accompanied by one of his black servant boys; and as they were proceeding, their attention was directed to numerous beetles running about upon the shore, which, when captured, proved to be specimens of a large species of *Brachinus*. On being seized, they immediately began to play off their artillery, burning and staining the flesh to such a degree that only a few specimens could be captured with the naked hand, leaving a mark which remained a considerable time. Upon observing the whitish vapour with which the explosions were accompanied, the negro exclaimed in his broken English, with evident surprise, "Ah, massa, they make smoke."

Another beetle, belonging to a different family *(Paussidæ)* is an accomplished cannoneer. This insect has been described by Captain Boyes, an English naturalist, who noticed that it discharged a fluid acidulous in scent and having caustic properties. The discharges were accompanied by sound and vapour. Says he, "A circumstance so remarkable induced me to determine its truth, for which purpose I kept it" (a Paussus) "alive till the next morning, and, in order to certify myself of the fact, the following experiments were resorted to. Having prepared some test-paper by colouring it with a few petals of a deep red oleander, I gently turned the Paussus over it, and immediately placed my finger on the insect, at which time I distinctly heard a crepitation, which was repeated in a few seconds on the pressure being renewed, and each discharge was accompanied by a vapour-like steam, which was emitted to the distance of half an inch, and attended by a very strong and penetrating odour of nitric acid."

But the strangest cannoneer in the entire animal kingdom is a naked mollusc called *Onchidium*. It inhabits the sea-shores of China and Japan, of the Malayan Archipelago, of North Australia, and of East Africa. This animal is shell-less, but its back is covered by a coriaceous or leather-like integument. The cephalic

or head eyes of *Onchidium* differ in no ways from those of allied groups, but its dorsal eyes (and it commonly has from twelve to sixty, one species having even as large a number as eighty, according to Lubbock; another species, according to Semper, has ninety-eight) are identical, as far as type is concerned, with those of vertebrate animals. These dorsal eyes have corneæ, retinæ, and lenses, anterior and posterior chambers, and "blind-spots." The "blind-spot" is peculiarly characteristic of the vertebrate eye: the optic nerve pierces the external layer of the retina; hence at this point sight is absent.

Now, of what use are these twelve, sixty, or ninety-eight eyes in the back of this creature, staring up, as they do, in all directions? They must subserve some useful purpose, otherwise they would not be present; and they do, as I shall now endeavour to show.

Wherever you find the *Onchidium*, you will be certain to observe likewise a very peculiar fish whose family name is *Periophthalmus*. This fish has the habit of leaving the water and coming out on shore, where it seeks its food, being enabled by its long ventral fins to make its way over the sands very rapidly in successive leaps, and *Onchidium* is its favourite food. The coriaceous back of this mollusc contains a multitude of glands which secrete a thick, tenacious substance—almost a concretion, in fact. In some preserved specimens that I examined not long ago, the contents of these glands *were* concretions, resembling minute shot. The preserving fluid, however, may have been instrumental in hardening the contents of the glands. The integumental pores of these glands are exceedingly small. Now, when Periophthalmus comes leaping over the sands, bounding several inches into the air at each leap, the staring dorsal eyes of Onchidium catch sight of the enemy. Immediately the mollusc contracts the coriaceous skin of its back and discharges thousands of viscous pellets from its dorsal glands at its foe. Periophthalmus, now alarmed and dismayed (overwhelmed, as it were, by this shower of shot from a masked battery), turns and flees for its life, and the watchful Onchidium is saved from a deplorable fate. Periophthalmus itself is a very uncanny-looking creature, with its pair of great staring eyes situated in the top of its head. As it leaps along the sea-

shore, using its ventral fins as legs, it looks like some strange goblin from the depths of the ocean, that has come ashore on mischief bent. No wonder Onchidium greets it with a shower of shot.

There are several families of very proficient sharp-shooters among the lower animals. The most expert, however, of them all is to be found in a family of fishes, genera of which are found in several localities both of the Old and the New World. These fishes are wonderful marksmen, and seldom fail to bring down the object at which they aim. Their weapons are their long, peculiarly-shaped muzzles, and their bullets are drops of water. The fish, after sighting its quarry, slowly swims to a favourable position within range; it then rises to the surface, protrudes its muzzle, and, taking rapid aim, zip! fires its water bullets and knocks its prey into the river. The struggling insect is gobbled down instanter, and the fish then proceeds in search of other game.

On one occasion, while I was watching some catfish that were swimming close to the shores of a pond, one of them gave a sudden flirt with its tail, thereby throwing a shower of water on a wasp which was busily engaged in digging out a pellet of clay. This unexpected downfall washed the wasp into the pond, whereupon it was immediately snapped up by the wily catfish. Whether or not this tragedy was the result of deliberate premeditation on the part of the fish I am not prepared to state; yet, taking everything into consideration, I firmly believe that it was.

The llama of South America is an expert marksman, though it never uses its craft in the procurement of its food. Only when annoyed and angry does it give an exhibition of its wonderful skill in hitting the object aimed at. The llama's weapon is its mouth; its bullet is composed of saliva and chewed hay.

Several years ago, at the Fair Grounds in St. Louis, I witnessed an exhibition of this creature's powers of expectoration, in which the victim was a country beau, who came very near losing his sweetheart thereby. This young man was one of those self-sufficient individuals who imagine that knowledge sits enthroned in the temples of their own personal intellects; that "what they do not know is not worth knowing." He was annoying the llama (the animal stood in the centre of its pen, probably fifteen feet or more

from its tormentor) by throwing clods of dirt at it and by beating on the rails of the pen with his cane.

I saw by the creature's action that it was angry; the rapid movements of its jaws indicated that it was preparing to attack its persecutor. I warned the young man, telling him what to expect; his sweetheart begged him to desist and to come away. But he treated my warning with derision, and told the girl that "he knew his business." Suddenly there came a whizzing, whistling noise, followed by a sharp spat. The young wiseacre lay supine upon his back, with his eyes and forehead plastered with a disgusting mixture of saliva, hay, and mucus.

"I hate a fool!" said the girl, as she shouldered her parasol and walked away.

I saw them again in the monkey-house some time afterward, but the man was a changed being: he had learned his lesson in decorum; he had been taught modesty by the good marksmanship of a llama.

FORESTRY IN SWEDEN.—The Crown forests of Sweden comprise more than one quarter of the entire wooded area of the country, and are managed with scrupulous care. The increase alone is cut, so that a productive forest is to stand for ever on Crown lands that are unsuitable for cultivation. More than this, the Government has entered upon an extensive system of planting trees on desolate and uncultivated areas, and these object-lessons have induced owners of private forests, especially the larger proprietors, to manage their timber lands, so they will become permanent sources of income. These facts, says an American contemporary, were communicated to our Department by the Hon. W. W. Thomas, United States Minister to Sweden, and they are of particular interest, not only to Sweden, but also to the United States and to Canada, whose lumber meets the Swedish products as its greatest competitor in the markets of the world. Since the forests in Sweden grow slowly, it has generally been supposed that the immense quantities exported would gradually exhaust the most important source of the nation's wealth; but from the facts stated it appears probable that the 47,000,000 acres of forests in the country will continue to be a source of income for all future time. The products of the forests now comprise nearly one-half of the total exports of the country in value.—*Journal of Horticulture.*

The Flora of the West Yorkshire Hills.

By Wm. Falconer.

WITHIN the area of the district, the flora of which I have chosen as the subject of this paper, the vegetation of the hills is made up in the main of grass, sedge, moss, fern, and other more inconspicuous plants. Moreover, there is a striking fitness in such comparatively insignificant organisms finding a home where the four winds of heaven can blow freely over them. Grasses and sedges are fertilised by pollen blown to them by the wind, and by the same agency the fruits and seeds of many plants, and the microscopic spores of ferns, mosses, and other lowlier plant-forms, are carried away to places where, under favourable conditions, they will begin anew the life-cycle of the respective plants from which they sprang. It is in this way that rocks appearing above the surface in time become clothed, in part at least, with lichen, moss, and other vegetable forms, which soften and adorn their nakedness.

It is to this garb of verdure, more or less pronounced according to situation, that we owe much of the picturesqueness and romantic beauty of natural scenery; it is this emerald robe of vegetation which gives so much pleasure to the eye when we gaze upon wide-spreading panoramas of hill and dale, meadow and wood, stream and rock. With equal readiness, and by the same means, Nature, if uninterfered with, will act upon the crude and neglected works of man, mantle them over with greenery, and make them gay with springing flowers.

A brief consideration of three factors which greatly influence the distribution of plants will place us in a better position to deal with those which grow on the Yorkshire hills.

(1) Elevation.—In passing from the Equator to the Poles, from the Torrid to the Frigid Zones, there is, keeping equal steps with the gradual change in climatic conditions, a gradual change in the character of the vegetation, from the luxuriant palms, banyans, and tree-ferns of the Tropics to the stunted willows and birches, mosses, and lichens of the Arctic regions. In ascending a mountain, a similar lowering of the temperature and a corres-

ponding change of vegetation take place, but at a much more rapid rate.

Dalton, the famous chemist, calculated that for every rise of three hundred feet, there is a fall in the temperature of 1° F. This rate of decrease, however, is not constant, but for the comparatively low elevations of Yorkshire it is approximately correct, and as such is sufficient for present purposes. By a simple calculation it is easy to find out that the difference in temperature between sea level and the tops of the highest hills in this county, two thousand four hundred feet in height, amounts to 8° F. The corresponding decrease of temperature caused by latitude is extended over 20°, or to a point as far North as the south of Iceland.

(2) MOISTURE.—Plants are influenced in their distribution by the presence or absence of moisture, in a greater or less degree, just as much as they are by increased or decreased temperature. Some love damp situations, and others prefer dry ones, and though many plants have remarkable powers of adaptation to altered circumstances, they often fail to thrive when taken from their natural surroundings and exposed to the opposite conditions, especially if the temperature also becomes changed.

It is a well-known fact that mountains, lifting their heads amongst the clouds, wring moisture from them, and from the warm, vapour-laden currents of air which impinge against their cold crests. Hence arise the numerous shallow pools, and the springs bubbling out of the ground near mountain summits, and the rivulets meandering down each little gill. The plants which make their home in elevated regions, find this humidity essential to their well-being.

(3) SOIL.—Many plants show a preference for certain soils, or, to be exact, certain constituents of the soil; and the spread of this knowledge amongst agriculturalists has led to their adoption of the system of rotation of crops. It is often possible to tell the kind of rock (using the word in its geological sense) which appears on the surface, from the flowers growing upon a particular spot, and often, too, from the flowers which are "conspicuous by their absence." For example, many of our common grasses which abound in fields, and yellow-flowered plants, like the dandelion and buttercup, are not found on a peaty soil, but, instead, heather

and ling, sundew, the purple Molinia, mat-grass, rushes, sedges, bog-moss, bilberry, and, high up above all, the cloudberry, a relation of the common bramble. The yellow-flowered Bog St. John's Wort (*Hypericum elodes*), however, is an exception to this rule. It can, and does, grow on a peaty soil. In sandy soils such plants as broom, hawkweed, sheep's sorrel, woodsage, foxglove, and birdsfoot trefoil abound, though they are not absolutely confined to such situations. On limestone, the heathers and bilberry, so common on a peaty soil, and foxglove so abundant on a sandy soil, are altogether absent, and the hairy violet, rockcress, and salad burnet are the characteristic plants. Clayey soils are distinguished by an abundance of white clover, sneezewort, coltsfoot, and fleabane, though these again are not absolutely peculiar to such soils.

In no case, however, does elevation exert its influence alone. It must always be considered in connection with, and in relation to, the degree of moisture, and the kind of soil. For instance, as we shall see hereafter, certain plants will grow higher up the slopes of limestone hills, which are as dry and warm as any in the county, in greater luxuriance than they will on damper hills of some other formation; and other plants will descend to lower levels, when they can find the moisture in the presence of which they are accustomed to grow.

The hills which extend along the Western borders of Yorkshire may be divided into two sections—a northern and a southern, each of which is marked by a characteristic geological formation. In the Northern section are numerous lofty and steep ledges of limestone rock approached by shelving slopes, covered with short, bright green, thin but nutritious grass. To the eye of a spectator suitably situated for observation, the prevailing tint of this region would be green, with here and there darker patches, the latter indicating the places where the limestone is overlaid by the millstone grit. Unlike the limestone, the millstone grit is devoid of the conspicuous grassy covering and is overspread with stretches of heather and peat. These last it is which impart the sombre touches to the otherwise bright landscapes. The whole of the southern section is capped by the millstone grit, and here its concomitant crown of dark, wild, and dreary peaty moorland is universal.

As the two sections differ widely in their formation and aspect, it follows naturally, from what has already been stated with respect to the joint influence of elevation, moisture, and soil on plant distribution, that an expression of this difference should be found in their flora. That this is the case is proved by facts, but it is not the writer's intention in the present paper to adduce the minute particulars necessary to establish them.

The most careless and indifferent observer must at one time or another have been struck with the great number and variety of plants growing on low-lying plains, and had his attention drawn to the prodigal floral display induced by the warmth of the sun and favourable conditions of soil and situation. If he quits the plain and begins to climb a lofty hill, he will find that the plants made familiar to him by their very abundance, if not known by name first of all become less numerous, both as regards species and individuals, and then drop out altogether, some at one level and some at another. Thus, on the Yorkshire hills, after reaching nine hundred feet, he would no longer see Dogwood and *Rhamnus*, and hawthorn would be scarce. He would find that the cultivation of field crops, vegetables, and fruit-trees ceases practically at eleven hundred feet; that bracken, so plentiful on the slopes between twelve hundred and seventeen hundred feet, completely disappears above eighteen hundred feet, at which height, also, the only trees are stunted specimens of mountain ash, birch, juniper, and hazel; at nineteen hundred feet the cross-leaved heath becomes uncommon; and above two thousand feet only ling is conspicuous.

It must not be imagined, however, that this process of elimination goes on without compensation; new species appear to take the place of those which become eliminated. At first, the new members of the flora are somewhat scarce, but they become more numerous as the elevation increases, though they never equal, either in variety or number, the plants whose places they have taken, and they find their most congenial home at or near the windswept summits of our loftiest hills.

Many causes combine to favour, on the one hand, the ascent of the lowland types, and on the other the descent of the mountain forms. It cannot, however, be said that, because a certain

fixed temperature has been reached, or a certain fixed height attained, plants have bounds set to their upward or downward distribution, over which they cannot pass. On the contrary, where the conditions—such as presence or absence of moisture, soil, aspect, shadow, or sunshine—are more favourable to them, many plants are able to grow higher up or lower down one hillside than on another. *Limosella aquatica*, *Hippuris vulgaris*, *Potamogeton densus*, usually lowland forms, may be found thriving at a height of from thirteen hundred to fifteen hundred feet on Malham Moor, and *Samolus Valerandi*, another lowland plant, at a height of one thousand feet, near Sheffield. The following mountain forms descend :—*Draba incana* to one hundred and fifty feet, *Gnaphalium dioicum* to one hundred feet, *Polypodium calcareum* to two hundred and fifty feet, *Actæa spicata*, *Myrrhis odorata*, *Sagina nodosa*, *Empetrum nigrum*, and *Lastræa oreopteris* to below one hundred feet.

In considering the flora of the Yorkshire hills, a distinction can therefore be made between plants preferring, and being more fitted for, the plains, and yet capable of growing and thriving at a greater or less elevation on hills, and plants flourishing best on bleak altitudes, yet descending to lower levels, the one set encroaching on the domains of the other, so that no distinct line of demarcation can be drawn between them. Further, as has already been stated, the limits of extension of any species, either in an upward or downward direction, varies in different localities, the limits being governed by influences to which plants, as living things endowed with a certain amount of ability to adapt themselves to circumstances, have responded; for they, like animals, have long been subjected to the influences of the external conditions of their environment, and these were not, and are not, always of a material kind, like local peculiarities of soil, situation, temperature, and degree of moisture. Those organisms, which have failed to respond to the requirements of their external surroundings, have been weeded out by death, leaving only those plants, which, through the vigour of their inherited constitution, produce hardy seeds, which, in turn, by virtue of their innate vitality, take possession of the waste places of the earth to the exclusion of their frailer brethren. These directing forces are still operative, and

chief among them in its power to determine the elimination of plants from the flora in either direction, is that competition which is the result of the crowded conditions under which plants exist.

The ascending series of plants are of Continental or Germanic origin, and are relics of the times when, instead of the separating waters of the German Ocean, there was a land connection between England and the Continent. It was across this now submerged land that they entered and established themselves in England. In time they overran the lower-lying districts, where the conditions of soil and temperature are most favourable to plant-life; whence, also, the crowding and competition resulting from such conditions, under the long continuance of which they have become inured to competition, and can wage successful war upon hardier plants which are less tolerant of crowding. They like warmth, but do not fear cold, and, therefore, ascend the hillsides, careless of competition and of the increasing cold, ceasing only when suitable situations in which to grow are no longer available. Thus, three hundred and thirty-nine of these plants in Yorkshire are found growing between one thousand and seventeen hundred feet, and as many as ninety above nineteen hundred feet, reaching their maximum limits where the soil is driest.

The following are a selection from those reaching a height of:

1000 ft.—*Corydalis claviculata*, *Geranium sanguineum*, *Hypericum elodes*, *Centaurea scabiosa*, *Origanum vulgare*, *Carex lævigata*, *Milium effusum*.

1100 ft.—*Calamintha clinopodium*, *Hydrocotyle*, *Anagallis tenella*, *Carex sylvatica*, *Festuca elatior*.

1250 ft.—*Genista anglica*, *Chrisosplenium alternifolium*, *Gentiana amarella*, *Phleum pratense*, *Equisetum limosum*.

1350 ft.—*Hippocrepis comosa*, *Carlina vulgaris*, *Lactuca muralis*, *Holcus lanatus*.

1500 ft.—*Arabis hirsuta*, *Polygonum bistorta*, *Asplenium trichomanes*, *Ceterach*.

1600 ft.—*Poterium sanguis orba*, *Parnassia palustris*, *Hieracium boreale*.

1700 ft.—*Drosera rotundifolia*, *Taraxacum*, *Carex panicea*.

1900 ft.—*Helianthemum vulgare*, *Viola palustris*, *Saxifraga tridactylites*, *Carex pilulifera*, *Molinia cærulea*, *Aira cæspitosa*.
2000 ft.—*Linum catharticum*, *Oxalis acetosella*, *Eriophorum vaginatum*, *Carex pulicaria*.
2100 ft.—*Alchemilla vulgaris*, *Euphrasia*, *Eriophorum angustifolium*, *Aira flexuosa*.
2200 ft.—*Draba verna*, *Erica tetralix*, *E. cinerea*, *Vaccinium myrtillus*, *Blechnum*.
2300 ft.—*Chrysosplenium oppositifolium*, *Galium saxatile*, *Luzula multiflora*, *Anthoxanthum odoratum*.
2400 ft.—*Cerastium triviale*, *Rumex acetosella*, *Luzula campestris*, *Festuca ovina*, *Nardus stricta*, *Lycopodium clavatum*.

The descending species have more opportunities for descending to lower levels than have the ascending species to rise to higher levels. Many places, though surrounded by lofty hills, are themselves at a comparatively low elevation—*e.g.*, Settle Bridge is four hundred and fifty feet, Buckden Bridge seven hundred and thirty-two feet, and Malham Cove six hundred and eighty feet above sea-level. Their flora partakes of the same character, and is composed, in the main, of the same plants as that of the heights around them. Then, again, the streams which are so common in hilly districts are oftenest in flood at the very time of the year when seeds are ripe—viz., in summer and autumn. In those seasons the rushing waters carry along with them the mature fruits of the plants, which, under normal conditions, grow in their banks, but which at those periods are wholly or partially submerged. In this manner, seeds from the hills are brought down to lower and warmer tracts, where, if circumstances favour them, they gain a footing and flourish abundantly, as, for example, *Saxifraga hypnoides*.

These streams, also, filled with water of a low temperature, have a tendency to chill the air, and the rocks in their immediate vicinity, so that Alpine plants find a degree of cold and moisture approximating to that of their native height, and it is in such situations, where a suitable soil is provided for them, that they descend to their lowest levels.

But as in the case of the ascending species, it is not cold alone

which determines the limits of their distribution; nevertheless, they form the characteristic vegetation of high altitudes not only in Yorkshire, but elsewhere in Britain. Some of them are survivals of the Glacial Period, when great ice-floods filled the Yorkshire dales to a height of fourteen hundred or fifteen hundred feet, and are, therefore, amongst our oldest floral types; but the greater number are supposed to have spread to England, across former land connections, from districts not ice-bound at a period of time immediately subsequent to the Ice Age.

The surface of this country, just emerging from its ice-cap, would present an appearance somewhat similar in character to that of the present-day Tundras of the north of Russia. The incoming plants spread over the whole of the country, but as the climate ameliorated and the soil improved, they withdrew from the cultivated tracts and made their home on the elevated moorlands, where they are still to be found (*e.g.*, *Empetrum nigrum*, *Juncus squarrosus*, *Galium saxatile*).

By virtue of their descent, they are endued with a nature capable of enduring very great cold, and flourish best at or near the summits of hills where alone they can obtain habitats, approximating most nearly in climatic conditions and soil to the frozen regions of the North, where they have their headquarters. This fact, however, does not hinder them from descending to lower levels, where the temperature is higher, so long as they can obtain suitable soil and sufficient moisture. Then, again, they are less numerous, both as species and individuals, than the ascending series. This arises from the restricted choice of fitting situations in which to grow, due to the smaller area of surface which is open to them. They are not subject, therefore, to such fierce competition as the rank-growing plants of the plains, and have not become habituated (if I may use the term) to conditions implying a struggle for existence against their fellows. Though cold suits their constitution, they do not fear warmth so much as they do competition, and meeting and mingling on their downward course with the ascending plants accustomed to the latter condition, cannot maintain their ground, and fail to establish themselves.

The following are illustrated selections from the Descending Species of plants in Yorkshire :—

Upward Limit.				Downward Limit.
2400 ft.	...	*Saxifraga stellaris*	...	1500 ft.
,,	...	*Lycopodium alpinum*	...	1000 ft.
,,	...	*Allosarus crispus*	...	700 ft.
,,	...	*Empetrum nigrum*	...	below 50 ft.
2300 ft.	...	*Poa alpina*	...	1850 ft.
,,	...	*Rycopodium selago*	...	below 50 ft.
2200 ft.	...	*Saxifraga aizoides*	...	1100 ft.
2100 ft.	...	*Lycopodium selaginoides*	...	400 ft.
,,	...	*Scirpus caespitosus*	...	below 50 ft.
2000 ft.	...	*Viola lutea*	...	600 ft.
,,	...	*Asplenium viride*	...	600 ft.
,,	...	*Vaccinium vitis-idæa*	...	350 ft.
,,	...	*Trollius Europæus*	...	300 ft.
1900 ft.	...	*Gnaphalium dioicum*	...	200 ft.
,,	..	*Polypodium dryopteris*	...	below 50 ft.
1850 ft.	...	*Arenaria verna*	...	500 ft.
,,	...	*Draba incana*	...	200 ft.
,,	...	*Solidago virga-aurea*	...	200 ft.
,,	...	*Vaccinium oxycoccus*	...	below 50 ft.
,,	...	*Pinguicula vulgaris*	...	below 50 ft.
,,	...	*Narthecium ossifragum*	...	below 50 ft.
1700 ft.	...	*Sesleria cœrulea*	...	350 ft.
,,	...	*Primula farinosa*	...	300 ft.
,,	...	*Polypodium calcareum*	...	250 ft.
1600 ft.	...	*Thlapsi occitanum*	...	500 ft.
,,	...	*Geum rivale*	...	100 ft.
1500 ft.	...	*Draba muralis*	...	500 ft.
1300 ft.	...	*Dayas octopetala*	...	1200 ft.
,,	...	*Bartsia alpina*	...	1100 ft.
1200 ft.	...	*Equisetum sylvaticum*	...	100 ft.
1100 ft.	...	*Polygonum viviparum*	...	600 ft.
1000 ft.	...	*Helianthemum canum*	...	900 ft.

The flora of the Yorkshire hills supplies one or two interesting problems in plant distribution: shore plants grow on the lofty ledges of the mountains, and some rare cryptogams thrive a great way from their usual homes. The situation of the three shore

plants in question., viz., *Armeria maritima*, *Silene maritima*, and *Plantago maritima*, so high up on the Craven hills, is an extraordinary one when we consider that they ordinarily thrive best and are most abundant near the sea. Scientists account for their presence on these elevations by the theory that the heights on which they now grow formed the cliffs rising above the waters of the ancient sea whose arms once filled the Yorkshire dales. Then, of course, they grew in a natural environment under natural conditions; but, when the rising land displaced the water, they were left behind, and their offspring still linger on where they are found to-day.

The ferns which occur so far away from their congeners are the rare *Asplenium lanceolatum* and Killarney fern, and the more frequent *Asplenium viride*. The first grows on an old wall on the moorlands near Sheffield. The next nearest station for it is in Wales, one hundred miles distant. There is no record of its having been introduced by human agency, and naturalists, in explanation of its strange occurrence, assert that the spores from the Welsh plants have been carried by the prevailing South-west winds to the crannies of the old wall, where, having effected a lodgment and found a congenial home, it now flourishes.

The presence of the second—a fern, as the name indicates, having its headquarters in the South-West of Ireland—is accounted for in the same way. Both of these rare ferns are of what is known as the Atlantic type, and entered England from the South-West at some very remote period, when there was, as geologists state, a land connection between Ireland and Wales.

The third, *Asplenium viride*, the green-ribbed Spleenwort, is, except in one instance in Yorkshire, restricted to the limestone, so that its occurrence at the head of the Wessenden Valley, near Huddersfield, on grit rocks, away from the limestone districts, though at a high altitude, puzzles naturalists very much.

In the Islands of Bermuda there are only seven native species of wild birds, while no less than one hundred and twenty-eight other species pay visits to the islands. Many of these are birds which pass the summer in the United States of America, and utilise the Bermuda Islands as a convenient winter resort.

Acid Fuchsine as an Agent for the Distinction of Bacteria.*

IN the *Abstract of Sanitary Reports* for August 23rd, 1895, Dr. E. Andrade Penny, assistant in the Hygienic Laboratory of the Marine-Hospital Service, has an article which is substantially as follows:

The changes of reaction brought about by different kinds of bacteria in the culture media where they are grown have not been carefully studied. There exists considerable variance of opinion among bacteriologists as to the reactions of the intestinal micro-organisms, more especially the *Bacillus typhosus* and the *Bacillus coli communis*. Brieger holds that the *Bacillus typhosus* produces an acid change. Klemensciewicz states that both these produce an acid reaction, which is more marked in the *Bacillus coli.* Thoinot and Masselin, on the other hand, say that, according to their experience, the *Bacillus coli communis* produces first an alkaline reaction, which gradually changes into an acid. Peré, after a careful investigation, states that in peptone bouillon made from meat less than forty hours old both the *Bacillus coli communis* and the *Bacillus typhosus* produce an acid which gradually changes to an alkali, the stages of acidity being shorter with the *Bacillus typhosus* than with the *Bacillus coli.* These reactions varied according to the time the meat was kept before use. Peré concludes that the different and opposite results of the investigators are due to the influence of the variable composition of the media, and not so much to the micro-organisms in question.

In view of these contradictory statements, the author says, and believing that very important and useful data for distinguishing bacteria and for the complete knowledge of their biological properties could be obtained from the careful study of the reactions they produce in different culture media, he has undertaken a series of experiments. The results obtained deal with those forms of bacilli which are usually found in the intestinal canal—viz., the *Bacillus coli communis*, the *Bacillus typhosus*, the *Bacillus proteus vulgaris*, the *Bacillus acidi lactici*, and the *Bacillus lactis aerogenes*.

* From *The New York Medical Journal.*

The experiments made with the spirilla will be the subject of another communication.

Aqueous solutions of acid fuchsine (fuchsine, S. Grübler) have been found to be excellent indicators for acids and alkalies. Solutions of this aniline dye lose their bright red colour in the presence of alkalies, and recover it or become more intensely red when acted upon by acids, either mineral or vegetable. It has been found out that 0·01 of a centigramme of caustic potash combines with 0·005 of a milligramme of acid fuchsine, and forms a colourless salt, the sensibility of which is that 0·00003 of a gramme detects 0·001 of a cubic centimetre of pure hydrochloric acid. The intensity of the colour assumed by the indicator is directly in relation to the amount of the reagent. Moreover, so far as has been observed, the addition of acid fuchsine to the culture media has not the slightest influence on the growth of the germs. To ten cubic centimetres of ordinary bouillon more than 0·5 of a cubic centimetre of a saturated aqueous solution of acid fuchsine was added without inhibiting the growth. This indicator has the advantage of being readily soluble in water; the solutions are entirely clear and transparent, and do not produce precipitates when the medium is rendered sufficiently alkaline to completely decolourise it. This is quite in contrast with other aniline colours, which have more or less these properties. It is known that Legrain used solutions of ordinary basic fuchsine for the same purpose. This has not in the author's hands yielded good results, because it is far less sensitive than acid fuchsine; the solutions are cloudy, and throw down a brownish-red precipitate in the presence of alkalies, which interferes with the tests.

These tests include many kinds of media, to which has been added the acid fuchsine, viz., ordinary peptone bouillon, beef tea, Dunham's peptone solution, Dunham's peptone solution with glycerin, somatose solutions, and somatose solutions with glycerin; also these media to which agar-agar and gelatin had been added. Of each medium two specimens were prepared, one pink, and the other decolourised, the difference being that the pink was exactly neutral in its reaction, while the so-called decolourised was slightly alkaline. The amount of acid fuchsine in both was about the same.

After many trials, says Dr. Penny, it was found that the most sensitive of the pink media was one that was exactly neutral and contained acid fuchsine in the proportion of 1 to 25,000 or 1 to 33,000, those decolourised having an alkalinity equal to 0·006 of caustic potash in every hundred cubic centimetres.

Neutral peptone bouillon is prepared in the usual way, and titrated for sodium chloride, so that it contains 0·5 centigramme to the litre. This is important, as an increase of the salt proportionately diminishes the growth of the bacteria, and hence interferes with the reaction. After the bouillon is prepared the acid fuchsine in aqueous solution is added, so that the medium contains the fuchsine in the proportion of 1 to 25,000 for the pink or neutral bouillon. The decolourised or alkaline bouillon is prepared by adding to every hundred cubic centimetres of the neutral medium 0·0006 of a milligramme of caustic potash and acid fuchsine in the proportion of 1 to 33,000.

After the addition of the fuchsine the bouillon is boiled for about half-an-hour, and then filtered, put into tubes, each containing ten cubic centimetres, and then sterilised in the usual way. It is observed that on heating the media the colour deepens, but on cooling the original colour returns; but it is sometimes paler.

Dunham's solution of peptone, with six-per-cent. glycerin containing acid fuchsine in the proportion of 1 to 33,000, has been found to be the best adapted for distinguishing the intestinal organisms. The decolourised solution is made in the same manner as for the decolourised bouillon; the advantage of this medium over others is that, on account of its absence of colour, it indicates the slightest trace of acid.

Instead of Dunham's peptone solution, somatose has also been employed in the same manner, adding to its solutions the same amount of salt and glycerin; it is not so satisfactory as Dunham's solution, owing to the deep orange tint of the solution, and before the proper colour was obtained the amount of acid fuchsine had to be increased, so that it contained it in the proportion of 1 to 2,500. Decolourised solutions are prepared in the same manner as others.

Solid media of agar-agar or gelatin are prepared from Dunham's or somatose solutions; the glycerin, however, should not be

added until they are neutralised and filtered, otherwise the media may not be clear and transparent. This is especially so with gelatin. The same amounts of acid fuchsin are added to each and they are neutralised in the usual manner.

The experiments, says the author, were made with one specimen of the *Bacillus proteus vulgaris*, one of the *Bacillus acidi lactici*, one of the *Bacillus lactis aerogenes*, six different specimens of the *Bacillus typhosus*, and five of the *Bacillus coli communis*. The specimens of the *Bacillus typhosus* and of the *Bacillus coli communis* were obtained from different sources—from New York, from the laboratory of the John Hopkins University, from the laboratory of the Army Medical Museum, from the Bureau of Animal Industry, and from the Hygienic Laboratory. Another specimen of the *Bacillus typhosus* was placed at the author's disposal through the kindness of Dr. Reed, of the Army Medical Museum, and designated by him by the name of blue typhoid, on account of the deep blue tint assumed by its cultures in litmus milk after a certain number of days. Each experiment was checked by plate cultures, so that in no instance was there any contamination by other bacteria. As a general rule, the cultures used in these experiments were bouillon cultures twenty-four or thirty-six hours old, and at a mean temperature of 98·3°F., although experiments were also made with cultures considerably older and grown under different conditions.

The following results were obtained by planting the micro-organisms already mentioned in acid fuchsine bouillon :

1.—After from six to eight hours the *Bacillus acidi lactici*, the *Bacillus coli communis*, and the *Bacillus lactus aerogenes*, develop a considerable quantity of acid, especially the *Bacillus acidi lactici* and the *Bacillus lactis aerogenes*. This acid reaction is indicated by the increased intensity of the pink bouillon or the appearance of the pink colour in the decolourised one.

2.—After twenty-four hours the acid reaction begins to disappear, the bouillon has a paler tint, and, at the end of forty-eight or fifty hours, they show a marked alkaline reaction, which increases rapidly until the pink colour entirely disappears, the cultures presenting then a yellowish hue.

3.—The *Bacillus proteus vulgaris* does not present an acid

stage from the beginning ; it alkalinises the medium so that at the end of twenty-four hours the pink bouillon has lost almost all its colour.

4.—The *Bacillus typhosus* shows the acid production of the initial stage later than any of the others ; it occurs after ten or twelve hours, and remains acid for a long period, varying from seven to ten days, and even longer ; then the acidity gradually disappears ; usually, by the twelfth day, the decolourisation of the pink medium is accomplished.

The changes of reaction of the cultures are shown by the colour assumed by the medium, and there will be a sharp distinction between the *Bacillus typhosus* and the other bacteria mentioned, so great that it is easy to distinguish it from the others. Especially is this well marked in fresh cultures. If the culture has been kept on laboratory media for a long time, this change is not so pronounced as was demonstrated in one of the specimens of the typhoid bacillus, which had been kept under prolonged cultivation. There was a marked diminution in its acid-producing power, making the difference between its culture and those of the *Bacillus coli communis* very slight. It was found, on further study, that this property was influenced by the character of the media, especially in the composition of the beef tea, which is by no means constant. Accordingly, other means were brought into use, bearing always in mind that such would always be of constant composition, and in which the differences of reaction change between the *Bacillus typhosus* and the other intestinal micro-organisms should be the same, notwithstanding the different ages and sources of the cultures used. This medium is the peptone solution prepared according to Dunham's formula with the addition of glycerin and acid fuchsine. The addition of the glycerin is essential to bring about the re-action, as no marked change is observed in simple Dunham's solution. The following results were obtained with this medium :—

1.—During the first forty-eight hours the *Bacillus acidi lactici* and the *Bacillus lactis aerogenes* produce a strong acid reaction, especially so with the former ; but the *Bacillus coli communis*, the *Bacillus proteus vulgaris* and the *Bacillus typhosus* do not produce any marked change.

2.—At the end of forty-eight or fifty hours the *Bacillus coli communis* and the *Bacillus proteus vulgaris* also produced an acid, so that the cultures became quite red.

3.—The *Bacillus typhosus* does not show any marked acid production until the fifth or seventh day, when it acquires the same tint as the others.

By observing the colour of the cultures, says Dr. Penny, after forty-eight or fifty hours, it is very easy to distinguish the pale pink or colourless culture of the *Bacillus typhosus* from the intensely red of the other organisms. As these results have been constant and have not shown any variation in a very long series of experiments made under different circumstances, this test is positive, establishing the presence of or distinguishing the *Bacillus typhosus* from the other intestinal micro-organisms, and especially from the *Bacillus coli communis.*

It will be noticed that the change of reaction brought about in the glycerin peptone solution with acid fuchsine is different from what takes place in the bouillon, for while the last stage in the bouillon cultures is one of alkalinity after a period of acidity (except in the case of the *Bacillus proteus vulgaris*, which has no initial acid stage), in Dunham's solution with glycerin and acid fuchsine no marked change is observed at the beginning, and the last stage is one of acidity. In this case the change of reaction is produced in all probability by an oxygenation of the glycerin; while in the case of bouillon the reaction is due to the influence of the germs on the inosite or any other hydrocarbonates.

Beautiful results were also observed by planting the *Bacillus coli communis* and the *Bacillus typhosus* in Dunham's solution with glycerin and fuchsine, to which agar agar or gelatin has been added. Stab cultures of the *Bacillus coli communis* and the *Bacillus typhosus*, made in the agar medium and kept at 98·3° F., showed the following results: Those of the *Bacillus coli communis* were pinker than those of the *Bacillus typhosus*, the pink colour being more marked along the stab, although it was diffused throughout the agar. The pink colouration increased, and on the third day the culture presented a brilliant red colour. On the other hand, the cultures of the *Bacillus typhosus* showed at the end of forty-eight hours a pink tint at the upper part of the stab,

from whence the colour was diffused to the upper stratum, gradually fading as it approached the periphery. The deeper strata were unchanged, the line of demarcation between the upper upper and the lower portions being sharply drawn. This condition was changed little by little, the lower portions gradually assuming a red colouration. Twelve days later the cultures of the *Bacillus typhosus* were red in their whole extent. This shows quite conclusively that the changes are due to an oxygenation of the media by the action of the culture. Shake cultures of the same bacteria were made with the same results in a much shorter time, the cultures of the *Bacillus coli communis* producing the characteristic bubbles on the third day. The red colouration of the cultures of the *Bacillus typhosus* began in this case by a narrow, superficial zone that gradually extended to the whole tube.

Shake cultures in Dunham's solution, with glycerin and acid fuchsine and gelatin, showed the difference between the *Bacillus coli communis* and the *Bacillus typhosus* in twenty-two hours after they had been planted, in spite of the fact that on account of extremely hot weather the cultures were kept at 50° F. As in the cases before mentioned, the *Bacillus coli communis* produced an acid change, making more intense the pink colour of the cultures, while the *Bacillus typhosus* did not produce any acid until the third day. It is thus seen that in this gelatin medium the *Bacillus typhosus* produces acid in a shorter time than in the agar or liquid media.

The *Bacillus typhosus* and the *Bacillus coli communis* were also planted in the somatose solution, with glycerin and acid fuchsine. The results were the same as those observed with Dunham's solution with glycerin, but the changes were brought about in less than twenty-four hours. At the end of this time cultures of the *Bacillus coli communis* exhibited a bright red colour.

It will be seen that, by growing the intestinal organisms in the medium mentioned above, we are enabled to distinguish organisms that are so often confounded with each other. Dr. Penny states that he is now experimenting with other intestinal bacteria, more especially the spirilla, and the results so far obtained are promising, and will be published.

Selected Notes from the Note-Books of the Postal Microscopical Society.

The Fructification of Mosses.

By Thomas S. Beardsmore. Plate XV.

By putting these slides into circulation, I think I am touching a subject which has not been brought before our members during the period of my own membership. These small plants always had a great attraction for me, and I once gave considerable time and attention to their study, but increasing business engagements compelled its discontinuance. So that preparing these slides has been a great pleasure to me, and I trust that their examination may not be without interest to our members.

The objects on slide 1 are all parts of the fructification of the mosses belonging to the natural family POLYTRICHACEÆ, and are intended to serve as an illustration of the construction of the sporophore generation when it arrives at maturity.

The *Polytrichaceæ* are an exceedingly interesting group. They differ much in size and habit, varying in the British species from one to eighteen inches in height. The British section includes eleven species, but over two hundred are known. The stem is highly developed, and in contradistinction to most other of the *Musci*, it is characterised by a sort of central woody axis. This family is usually regarded, especially when considering the noble tree-like habit of some exotic species, as standing at the head of all mosses. By reference to Pl. XV., Figs. 1, 2, 3, those who have not as yet paid any attention to the subject may more easily follow the notes.

The fructification of the mosses is called a capsule, and is composed of a spore case, which varies in size and shape according to the species, but the one under consideration may be seen to consist of a tubular extension of the stem, or seta, in the shape of a bent cylinder. This cylinder terminates in an annular swelling called the "annulus," and upon which fits a lid called the "operculum," which is here sub-hemispherical at the base, and continued into a long beak. This lid falls off when the

fruit is ripe, and is itself covered with another vestment called the "calyptra" (the origin of which will be described in another place), which is so strongly developed in some species of this family. When the fruit is ripe, the first part, as a rule, to disappear is the calyptra, then the operculum, which discloses to view a beautiful arrangement of teeth fringing the mouth of the spore case, and which is known as the "peristome." These teeth are all united to a membrane known as the "epiphragm," or "tympanum," which serves as a protection to the interior of the spore case after the dehiscence of the operculum. It will thus be seen that the fructification of the lowly moss is a very complicated arrangement.

The objects represented in Fig. 1 are all from *Atrichum undulatum*, or, as it is sometimes called, *Catharinea undulata*. At *f* is shown the fully developed capsule, from which however the calyptra, *c*, has fallen, showing the long pointed operculum still adherent. Detached opercula may be seen at *h* and *i*, while at *g* and *j* are shown two capsules from which the opercula have fallen, giving a side view of the previously enclosed peristome. At *d* and *e* are two examples of the peristome and the epiphragm enclosed. There are thirty-two of these peristomal teeth in the species under consideration, but in some members of the family they number sixty-four, as in *Polytrichum juniperinum*. Occasionally they may be seen united in pairs.

The tympanum, or epiphragm, is one of the distinguishing features of the family, and has special structural modifications, according to the species. The caliptra, *c*, is not a salient feature in this species, but it is a very striking object in some, as in *P. urnigerum*, the calyptra of which is seen at Fig. 3.

Fig. 2 shows the same organ from *P. juniperinum*, and Fig. 5 is from *P. piliferum*. It will thus be seen that the calyptra is a very variable organ, even in members of the same family, and is a great help in the determination of species. *a* and *b* (Fig. 1) are two halves of the same capsule; in *b* may be seen the columella in the centre of the chamber; it is from differentiated cells of this organ that the spores take origin. The columella of this species when in the living state is cylindrical, but in some species, as in *P. aloides*, it is four-winged, as may be seen by reference to Fig. 4.

When in a growing state, the operculum fits over the peristome very closely, and in the specimen under observation the impress of the teeth on its inner surface may be very plainly seen. Detached opercula are shown at *h* and *i*.

Examination of the entire fructification of *P. piliferum* proves that the calyptra would seem to perform the part of a very serviceable overcoat. These highly developed calyptra (Figs. 2 and 5) present a very different appearance from the calyptra of *Atrichum undulatum* (*c*, Fig. 1), but by careful examination it may be seen that the specimen, though membranous, is not entirely devoid of the woolly arrangement, as is evidenced by the spinulose fibres at the apex. When all is ready for the liberation of the spores, the epiphragm (which originally closed up by means of fistular processes, or mammæ in some species, the interstices of the peristome) now becomes shrivelled, and the spores escape between the teeth of the peristome.

I have selected this moss for a detailed description as it is one of the most beautiful as well as one of the most common mosses we have, and is generally one of the first to attract the attention of the rising biologist. I give a list of the synonyms by which this moss is known.

Atrichum undulatum, Linn.	*Catharinea Ehrharti.*
Bryum phyllitidis.	*Mnium undulatum.*
B. phyllitidysolium.	*Polytrichum undulatum.*
B. undulatum.	*Callibryum polytrichoides.*
Catharinea callibryon.	*Callibryum undulatum.*
Catharinea undulata.	*Oligotrichum undulatum.*

It must not be supposed the fructification of all mosses are constructed on lines corresponding with the degree of development exhibited in *Atrichum.* Here we have thirty-two teeth (these teeth are always in number a multiple of four). The members of the tribe *Georgiaceæ* are characterised by having only four teeth (see Fig. 4). Those of the tribe *Andreacaceæ* have no peristome at all, but the capsule itself dehisces longitudinally, forming four to six slits, through which the spores escape, as in Fig. 5. In some cases the spores are set free simply through the decay of the capsule, as in *Archidium alternifolium*, nature providing no other method of liberating them (see Fig. 6).

The capsule may be globular, straight, curved, upright, drooping, corrugated, ventricose, or almost any shape from a sphere (Fig. 6) to an upright cylinder (Fig. 7). It may be twisted, striated, or irregular, as in Fig. 8. The capsule proper may be placed on a large swelling of the setæ, termed an "apophysis," when the latter development is sometimes, relatively, a large bulk of tissue compared to the true spore-bearing organ at its summit, as is instanced in *Splachnum vasculosum* (Fig. 9). This apophysis, *i*, in some species of *Splachnaceæ*, often gaily coloured, as in *S. pedunculatum*, see Fig. 10.

The capsule may be immersed in the leaves, as in *Grimmia apocarpa*, and the whole plant may be only about one-eighth of an inch in height, as in *Pleuridium axillare* (Fig. 11), or it may be borne on a long seta, as in *Atrichum.*

The stem may be almost absent, or it may branch and spread in all directions, often giving rise to the most beautiful design, as in *Thamnium alopicurum*, and *Thuidium tamariscinum.*

The peristome, one of the most beautiful objects in nature, may be single, as shown in Fig. 4, or absent, as in Figs. 5, 6, and 7, or double, as in *Hypnum* and *Brachythecium.* It may stand out like an array of needles, as in *Racomitrium canescens,* or it may fold over the edge, like the teeth of *Tetraplodon*, or as in Fig. 10. The teeth may be bent obliquely with lateral projections, as in *Funaria*, or they may be twisted into a string, as in the majority of the *Barbulas*, or as shown in Fig. 13. Sometimes, as in *Orthotrichum rivulare,* may be found three types of teeth, viz., eight broad, eight filiform, with eight short ones alternating, as in Fig. 12.

Hitherto we have been considering the normal fructification of the Moss family, but these plants frequently multiply in another manner, namely, by means of buds, or "gemmæ," which are detached from the parent plant, and which under favourable conditions reproduce the mature form from which it originated. They are often produced upon the enlarged midrib of the leaf (when the leaf has one) as in *Ulota phyllantha :* in fact it is the usual method of reproduction in this species. Hobkirk, in the 1884 edition of *British Mosses,* says that "the fruit is not known," but it has since been found, as Braithwaite gives a figure of it in

his *British Moss Flora* (August, 1889), see Fig. 14. These gemmæ appear to consist usually of seven cells, with rather strongly thickened cell walls of a fuscous colour. These gemmæ occur in such numbers on the upper leaves as to give them a distinctly reddish appearance, so that in this particular instance their presence can be instantly detected by the naked eye. Some authors refer to the buds as "propagula." The scars are plainly visible with a one-fifth objective when the gemmæ have been detached.

In *Tortula papillosa* these gemmæ are borne upon the nerve, within the boundary of the lamina, see Fig. 15, and remind one somewhat of *Globergerina*. In *Georgia pellucida* the gemmæ are lentiform, and are accompanied by paraphyses. In this particular instance the gemmæ are regarded as altered antheridia, or male organs, see Fig. 16. Paraphyses are nearly always found accompanying and intermingled with the antheridia of mosses, and are usually regarded as being modified or abortive antheridia. They are also met with in the *Ascomycetes* and many other divisions of Acrogens. In *Aulacomnium androgynum* these gemmæ are borne on a separate stem like the capsule.

There is yet another method of reproduction known. In *Leucobryum glaucum* it is common to find a tuft of radicular tomentum developing a cluster of new plants, which, falling to the ground, grow to a new colony, and thus compensate for the rarity of the fruit, see Fig. 17. This species is the only representative of the tribes found in Europe.

THE LEAVES OF MOSSES are objects of great interest, and present some curious modifications, such as, I think, cannot be equalled or paralleled in any other class of plants. The leaves of *Pterygophyllum lucens* (Fig. 22) form very good objects for amateur photography. In the *Polytrichaceæ* many of the species bear vertical laminæ on their leaves, see Fig. 18, and this is also a great help in the determination of species.

The members of the tribe *Fissidentaceæ* present a remarkable divergence from the ordinary type. According to Braithwaite the leaves are "Scalpelliform, the upper basal part conduplicate and amplexicaul." In simple language, the tribe is characterised by a wing uniting with the laminæ, forming a keel-shaped leaf which

embraces the stem. This will be better understood by reference to Fig. 19.

Many of the *Diatomaceæ* are characterised by having a zone of very lax tissue at the base of the leaf, and a very small-celled areolation in the upper part, see Fig. 29. In some of the *Tortulaceæ* the lamellæ (referred to before in *Polytrichaceæ*) are decurrent, and in the form of a membrane, instead of in sub-algal thread, as in Fig. 18. *Tortula lamellata* is known as having four of these decurrent lamellæ on the upper third of the leaf, as shown in Fig. 21.

The leaf-cells of the sphagnum exhibit a very curious departure from the ordinary type, for instead of being small and polygonal, as (with a few exceptions) is the rule in most mosses, they are large and elongated. They exceed in size the cells of *Pterygophyllum*, they do not contain any chlorophyll, but have a loosely coiled, spiral fibre of secondary tissue in their interior.

Their cell-walls are pierced by large rounded apertures, by which thin cavities freely communicate with one another, as is sometimes curiously evidenced by the passage of animalculæ which make their habitation in those small chambers. Between these coarsely spiral cells are some thick-walled, narrow, elongated cells, containing chlorophyll; these, which give the leaf its firmness, do not, in the very young leaf, differ much in appearance from the others, the peculiarities of both being evolved by a gradual process of differentiation. A half-inch objective will suffice for their examination. Further information may be gathered from Dr. Dallinger's edition of *Carpenter on the Microscope*, pp. 598-599, but *the* great work on the subject is Braithwaite's *Sphagnaceæ*.

The leaves of mosses present the best possible method of studying in the living state the manner in which the chlorophyll is packed in the cells. The leaves of *Funaria* are usually chosen, but the "prothallia" of ferns are equally good for the same purpose. The lamina of mosses being one cell thick, there is consequently no under-portion to obscure the vision, and the grains are larger than in most plants of a higher development.

I feel a degree of hesitation in directing attention to a subject so elementary, but the division of the individual grain into two

may here be followed with great ease. The round grain becomes oval; then a medial constriction takes place; the narrow part finally divides, and the one grain becomes two, which remains in contact for a short time. With a high power the chlorophyll grains appear to be finally punctate, and thus betray a network structure.

Specimens should be mounted in acetate of potash, but observation is best conducted on a fresh material. With careful examination of the Pyrenoids the starch enclosures may be seen; but as chemical re-agents are required to show them to their best advantage, I refer our readers to Hillhouse's edition of *Strasburger* as containing all the information they desire.

Moss is not a plant of very great use to man. The Laps use it to stuff mattresses, etc., and in the Midlands it is used in wells, when running sand gives trouble, but its uses are very limited. It occupies an important place in the evolution of plants, and is of considerable interest from a paleo-botanical point of view. The sphagnums, which are hardly true mosses, are a large ingredient in peat, and in a more recent state form the Peat-Moss Litter, so extensively used for stables. It will be seen that the *Andrœaceæ* form a sort of connecting link between the true mosses and *Jungermanaceæ*.

EXPLANATION OF PLATE XV.

Fig. 1.—*a*, Capsule of *Atrichum undulatum*, divided longitudinally; *b*, ditto, showing Columella; *c*, Calyptra; *d* and *e*, Peristoma and Epiphragm; *f*, Mature capsule without calyptra, which is shown at *c*; *g* and *j*, Mature capsules without calyptra and operculum; *h* and *i*, Operculum.

,, 2.—Shows the mature capsule. *a*, Spore case; *b*, Calyptra; *c*, Operculum; *d*, Annulus; *e*, Seta.

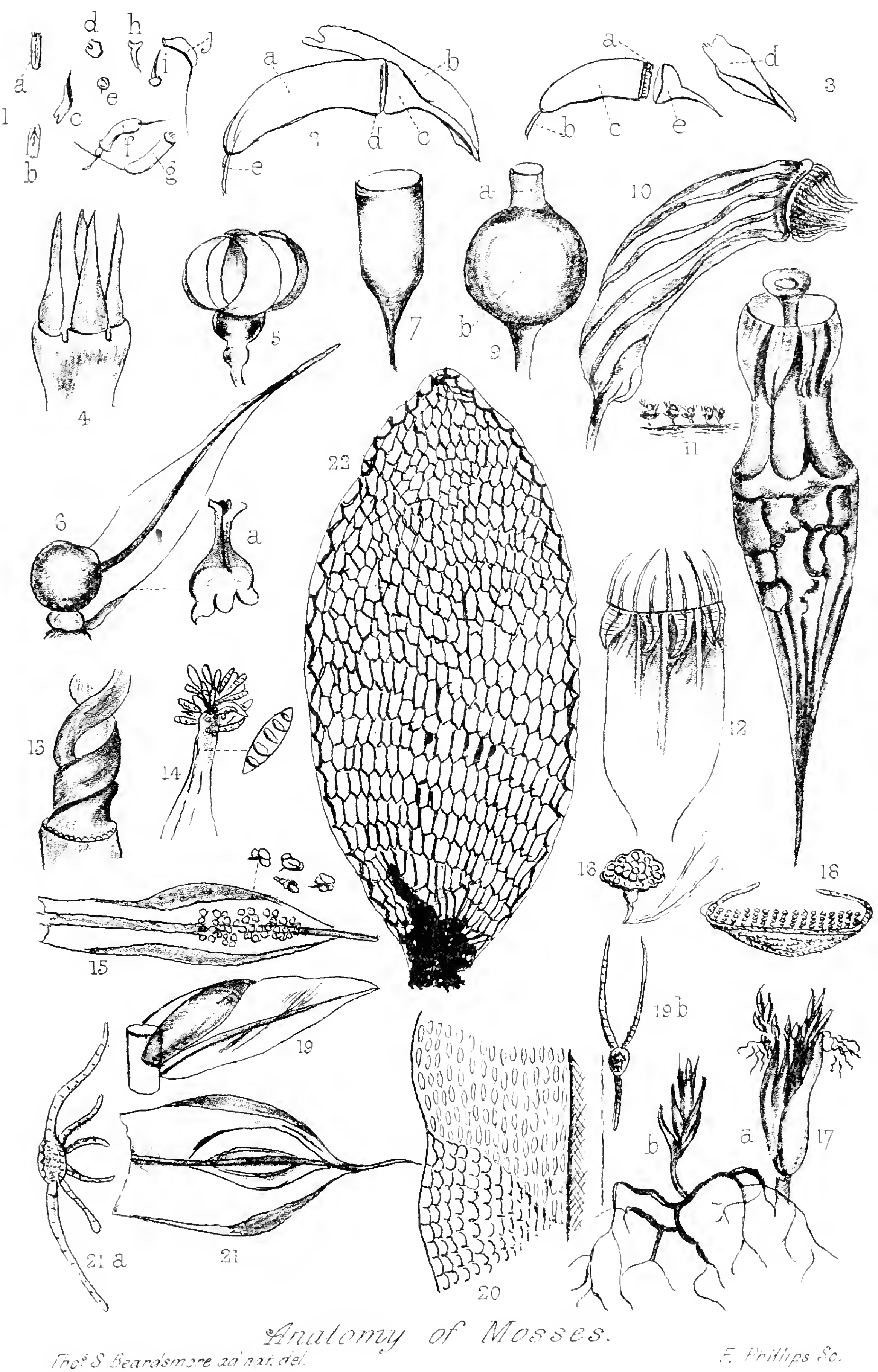
,, 3.—The same fruit after removal of the calyptra and operculum, thus disclosing the peristome previously concealed. *a*, Peristoma; *b*, Seta; *c*, Spore-case; *d*, Calyptra; *e*, Operculum.

,, 4.—Peristome of *Georgia pellucida*.

,, 5.—Dry Capsule of *Andræa petrophila*.

,, 6.—Capsule and perichætral leaf of *Archidium alternifolium*. *a*, Calyptra.

,, 7.—Capsule of *Pottia Heimii*, showing absence of peristome.



Anatomy of Mosses.

Thos S Beardsmore ad nat. del.

E. Phillips Sc.

Fig. 8.—Capsule of *Leucobryum glaucum*.
,, 9.—Capsule of *Splachnum vasculosum*. *a*, Spore-case; *b*, apophysis.
,, 10.—*Splachnum pedunculatum*.
,, 11.—Plants of *Pleuridium axillare*.
,, 12.—Peristome of *Orthotrichum rivulare*.
,, 13.—Peristome of *Tortula marginata*.
,, 14.—Gemmæ of *Ulota phyllantha*.
,, 15.—Leaf of *Tortula papillosa*, with gemmæ.
,, 16.—Lentiform gemma of *Georgia pellucida*.
,, 17.—Showing—*a*, Young plants at apex of *Leucobryum glaucum* and *b*, Young plant isolated.
,, 18.—Section of leaf of *Polytrichum*, showing vertical lamellæ.
,, 19.—Leaf of *Fissidens osmundoides*. *a*, Section of above through the basal part.
,, 20.—Part of base of leaf of *Dicranum spartum*.
,, 21.—Leaf of *Tortula lamellata*. *a*, Section of same.
,, 22.—Leaf of *Pterygophyllum lucens*, from a photograph.

Drawn by T. S. Beardsmore.

Notes by Various Members.

Hairs on Leaf of Jerusalem Artichoke (*Helianthus tuberosus*).—Each of these hairs, as well as a group of cells around its base, is filled with a deposit of silex. Viewed with *reflected light*, these look like beautiful mosaic work in white enamel. The silex derived from the soil must be held in solution by the sap and carried by it to the surface of the leaf, where it is deposited in the hairs and in the cells in connection with them. The same leaf, if viewed with *transmitted* light, will show (though imperfectly) the connection of these hairs with the fibro-vascular bundles in the leaf. A coloured fluid, absorbed by the cut end of the leaf-stalk, has found its way to the roots of many of the hairs, and in some few cases even into the tube of the hair itself. For viewing the hairs as opaque objects, throw a strong light on the surface by means of a bull's-eye condenser and turn off the mirror. Any objective from 2 in. to half-an-inch may be used. F. Bossey.

Tubes of Melicerta ringens.—To see the beauty of this struc-

ture a half-inch objective should be used. In the *Monthly Microscopical Journal* for Nov. and Dec., 1877, there is an excellent paper by Judge Benwell "On the Building Apparatus of *Melicerta ringens*," from which I extract the following:—"The building apparatus of *M. ringens* consists of a combination of very various parts, in which combination the pellet organ is but one item. It is requisite that the pellet should be specific in shape when made, and in situation and in altitude when laid; the materials have to be specifically selected; their safe arrival at the pellet organ specifically insured, and all in the presence of very considerable opposing risks. To understand how these results are arrived at is one of the exquisite enjoyments of microscopic research."

After a very able exposition of the mechanism of the brick-making and building operations, which all who can should read, Judge Benwell says:—

"I may be unduly prejudiced in favour of my subject, but the apparatus of *M. ringens* always fills me with wonder and delight. It stands, in my judgment, so completely and instructively *per se*, it is so complicated, yet so accurate in its performance, the apparent intelligence of this 'speck of life' is so extraordinary, the results are so unexpected, so many points, too, of the animal's economy have to be considered in estimating the final result; and although it is true that we have, even from *Stentor* upwards, a series of rough building going on, which result in more or less workmanlike habitations, yet the leap from the very best of them *(Limnias)* up to *M. ringens* is to my mind a vast, a great stride, and just as great as the step from a lath-and-plaster cottage up to a house built of patent stone, made by the aggregation of sifted sand forced together in a mould and deposited by the action of highly complicated machinery. To start from *Limnias* and reach by development an animal which, in the size of the tenth of an inch, shall make a thousand separate bricks, each brick shaped like a rifle-bullet, convert a sphere into a complicated figure, turn the brick round, lay it in its right place and altitude, make another, lay that next it, throw away its waste material, choose its material, keep up five, nay six, separate and distinct currents, all necessary to its object, never let them get confused, though there is not the one-hundredth part of an inch between either of them,

and go on eating all the time, I confess utterly seems to me to confound the power of imagination. You want not merely a pellet organ; that is nothing. You want a set of setæ at the back of the head, and a pair of hooks on each side of them; a moveable nose to pinch the brick against the chin and lay it on the wall, the cushion to direct and an apparatus to guide the materials, a cleft in each side of the pellet organ to conduct them, and the intelligence (or say improved 'vital force') to use all the apparatus when you have got it, and make it work as one machine. Even with *Limnias* to help me, still the last form of apparatus I should have dreamt of reaching would have been such a one as that before us. As to whether it can be reached by degradation I know not; but I confess myself unable to see how it is impossible to evolve it out of anything less advanced in organisation than itself—at any rate, by any process which does not end in first creating and dropping out a score of intermediate non-existent forms just at the very point where we most want their presence and have a right to expect their existence, and where the actual existence of so many, and the extremely favourable and established conditions under which the development has been going on fully entitle us to require the non-existence of the others to be strictly accounted for." F. BOSSEY.

[We hope shortly to be able to reproduce the entire text of this exceedingly interesting article, together with the two plates by which it is accompanied.—*Ed.*]

Melicerta ringens.—The building of a tube by *Melicerta ringens* is, perhaps, one of the most interesting things to be seen in "Pond Life." I have watched the preparation of the "Brick" in the cell from the moment of the last brick being laid until the new one was placed in its position, and I am decidedly of opinion that it is either globular or cylindrical in shape. It is kept rotating in its round cell the whole time of its formation, and the shape as seen in the tube is probably due, like the cells of the honeycomb, to mutual pressure of the soft bricks. F. J. SKELTON.

The Plates and Hairs in the Jerusalem artichoke are very similar to those of the beautiful *Borago Zeylanica* from Mauritius, and are very striking; but I question whether they are *siliceous*;

my friend who described it called them *calcareous.* Would some of our members dry, and thus test, a piece of common Borage? If calcareous, hydrochloric acid would, I suppose, dissolve them; but if siliceous, they would, I suppose, stand the acid. A. SMITH.

Æcidium bellidis.—This illustrates one phase in the "Alternation of generations" in the micro-fungi. These æcidium cups or "Cluster cups" may often be found on backs of leaves, especially at this time of the year—indeed, it is difficult to find a leaf of Coltsfoot (*Tussilago farfara*) which does not serve as a host for them. The varieties occurring on different plants are very similar, and receive their names from their host, thus—*Æ. tussilaginis* is found on the coltsfoot, *Æ. bellidis* on the daisy, *Æ. primulæ* on the primrose, and so on. The outer sheath is filled with filaments and spores which separate into the minute æcidiospores. They are produced from individual cells at the base of the cup, called "basids," though the formation, or rather the manufacture, of basiospores can be much more easily demonstrated on *Penicillium crustaceum.*

The basiospore is also called the æcidiospore when, as in the instance of the object under discussion, it is developed within an *Æcidium.* The ripe æcidiospore germinates only on the leaves and stems of grasses and such like plants, and ultimately produces "Teleutospores," which are two-celled. Immediately upon germinating, the æcidiospore generally produces one-celled spores, known as "Uredospores," which germinate very rapidly and constantly reproduce the *same* type. By the production of uredospores from æcidiospores hyphæ is limited, and generally only teleutospores are formed. The teleutospores fall upon the barberry, the coltsfoot, etc., and from them arise the æcidium cups. It will thus be seen that two plants are necessary for the life-history of these alternating organisms.

So far as is known, the generations are perfectly asexual, though rudiments of supposed sexual organs, called "spermagones," are found on *Æ. berberidis*, opposite the æcidia—*i.e.*, on the upper side of the leaf.

These micro-fungi seem to be extra specially adapted to their condition of existence. By appropriating as their pabulum the

elaborated cell-sap of their more industrious relations, they have more energy to throw into the work of reproduction, more crops of spores are found. They seem to have nothing parasitic on them—no enemies, unless our old friends the Bacteria pay them an occasional visit. THOS. S. BEARDSMORE.

Signalling through Space without Wires.

AT the Royal Institution on Friday, June 4th, Mr. Preece delivered a lecture, of which the following is an abstract*:

"Mr. Preece, who is Chief Engineer of the Post Office Telegraph Department, has been an active investigator in this direction, and the accounts of his own experiments, as well as those of Marconi, proved full of interest. Science, he said, has given us in telegraphy what may be called a new power and a new sense, the discovery of which is among the greatest of the Victorian era. He proceeded to give a summary of what is known respecting the ether and the nature of wave-motion. The theory that light and radiant electrical energy were identical in kind had been built up by Clerk-Maxwell, and been confirmed by the test of experiment by Hertz. Through the kindness of Professor Silvanus Thompson, who had lent a model for the occasion, such as recently exhibited at the Royal Society's conversazione, the lecturer was enabled to graphically illustrate wave transmission, but the waves dealt with in the new telegraphy, instead of vibrating with a frequency of once or twice per second, were vibrating with a speed of millions or hundreds of millions of oscillations per second. All radiations, it was explained, are of one kind, and differ only in frequency, so that, generally speaking, what can be done with light rays can also be done with electrical rays, or radiant energy of any kind whatsoever. By means of diagrams the different directions assumed by lines of force emanating from an electrically-charged body were shown. From a charged brass sphere the lines radiate away straight in all directions; if, on the other hand, the section of a wire con-

*From the *Pharmaceutical Journal*, June 12th, 1897.

ducting a current be regarded, the lines circle round and round the wire. Whereas Marconi had devoted his attention to radiations of the former kind, he himself had confined his attention to the study of the latter.

"Some few years ago the authorities of the Post Office had been puzzled to account for the fact that messages to the north of England were being deciphered at an office in Gray's Inn Road not in any way connected with the system, and finally it was found that the messages sent by wires underground were communicated by induction to wires eighty feet above the ground. Through this circumstance the matter had been taken up experimentally by Mr. Preece, and it was found that the influence of a current was perceptible not only at eighty, but at a distance of two thousand feet. The experiment of sending a message across Loch Ness, a distance of over a mile, was afterwards successfully carried out, and on the Bristol Channel, in signalling from Lavernock Point, near Penarth, to islands off the coast, still greater success was met. By using a mile and a quarter of wire at Lavernock Point, and about six hundred yards of wire on the island of Flatholm, messages were communicated over a distance of three miles. Later, with the use of the same apparatus, signals were sent as far as Steepholm, an island five and a quarter miles distant. An alternating current, making about 250 alternations per second, was used as the source of energy.

"To illustrate the principle, a coil consisting of several large loops was connected with a telephone, and held opposite a similar one attached to a battery. When a current was caused to pass in the latter, connection being made and broken by a Morse key, a sound was emitted by the telephone due to the induced current. If one coil was held in a plane perpendicular to that of the other the sound ceased; it also diminished when one coil was made to recede from the other. Another model more nearly illustrated the apparatus actually employed. It consisted of a pair of rectangular wood frames facing each other from opposite sides of the theatre on which the wires were coiled. The induction from one to the other of these frames could not, however, be demonstrated to the whole audience, the sounds produced not being so loud as those

from the other, but they are clearly and distinctly heard when the ear is applied to the telephone.

"The value of the system had been proved upon an occasion when telegraphic communication was interrupted between the island of Mull and the mainland, the post office telegrams being transmitted by this method across the Sound of Mull. Mr. Preece explained that the difficulty upon that occasion had been no greater than then in the lecture theatre, for the law that had been elicited demanded only that a length of wire should be used equal to the distance over which it was required to send the signals. Experiments had been carried out at a lightship on the Goodwin Sands with the object of transmitting the signals through water, but these had proved fruitless. Water being a conductor, it had acted as a screen, interfering electrical currents being developed in it, while the hull of the ship had also interfered.

"A description was now given of Marconi's system. Marconi, a pupil of Righi, had, one might say, gone back to first principles. He employed the radiant energy emitted by a spark passing through a series of four solid brass spheres. Of these four the middle pair are larger than the outside two, from which they are separated by air, they themselves being separated from each other by a thin layer of oil. The principle known as Righi's is based on the fact that solid brass spheres are twice as effective as hollow ones—one of the few results arrived at in the first instance by mathematical investigation. To receive the impression of the rays emitted in this way an apparatus is used, the principle of which depends upon the fact that under the influence of these rays a small quantity of metal dust, consisting of 96 parts of nickel and 4 of silver, with a minute trace of mercury, becomes polarised and acts as a conductor, joining the ends of a pair of wires, between which it is placed in a glass tube. A current thus passes which puts a relay in action, and a hammer is made to tap the glass tube. The effects of this are two—namely, to give a signal representing either a dot or a dash, as in the Morse system, and, moreover, to shake down the adhering dust, now again depolarised, and so interrupt the current. The results obtained by this method are even more surprising than those of the method first described. At its first trial on Salisbury Plain it was made to act at a distance

of one mile and three-quarters. This distance was increased in later experiments, and by transmitting the signal from a height, as from a flying kite, it becomes readable at a distance of eight or nine miles. It remains to be seen how far it can be made to act, but it is evident that the higher the apparatus is placed the more favourable are the conditions, and the distance is proportional to the energy of vibration.

"A curious feature of this method is that no matter in what direction the receiver is placed with respect to the transmitter the effect is the same. Demonstrations were carried out at the lecture-table, the apparatus actually used for long distances being employed. Messages were sent from one part of the building to another through two or three walls, and the receiver appeared to respond to the signals equally well when shut inside a large sheet-iron box. Messages may be sent from valley to valley even when high hills intervene. As to the secrecy that could be maintained with the use of such a method, the lecturer explained that nothing was left to be desired, for a receiver must be tuned to the frequency of the transmitter, and among thousands of different frequencies it would be difficult to find that of an unknown transmitter. The subject was now only in its embryo stage, and had yet a vast field before it. Advantages to be reaped in commercial, military, and marine undertakings could hardly as yet be anticipated."

A SHORT-LIVED ISLAND.—In 1867 a new shoal was discovered in the group of the Tonga or Friendly Islands. In 1877 smoke was seen over the shoal. In 1885 the shoal had become a volcanic island, more than two miles long and 240 ft. high, and a fierce eruption was taking place within it. In 1886 the island had begun to sink in dimensions, although the next year its highest point was 325 ft. above sea-level. In 1889 its height had diminished one-half and the ocean close around it was more than a mile deep. In 1892 the island rose only about 26 ft. above sea-level. According to the latest information, its complete disappearance, under the action of the waves, will not be long delayed.

Microscopical Technique.

Double-Staining Spinal Cord, etc.—Albertrand, of Vienna, describes a new method of staining the spinal cord and its membranes with a double colour, consisting of chloride of iron and tannin. The section is first submitted to a 50 per cent. solution of the sesquichloride of iron for ten or fifteen minutes, then washed in water, and next submitted for one or two hours to a twenty per cent. solution of tannin, after again washing. The colour is differentiated by Pal's solution. These give sharp, clearly defined images of the nerve fibres in the grey substance, both of the spinal cord and the brain, which is a great improvement on Weigert's hæmatoxylin. The alcoholic preparations can be clearly brought out with this method, which is difficult to obtain with Weigert's solution The colouring of alcoholic preparations affect the remnant of the sheath alone, as the spirit extracts the myelin, leaving only the framework of the sheath to be coloured. How this was acted on he would not venture to explain, but believed the changes to be similar to that in Kühn Ewald's *Neuro-Keratingerüst.* With the differentiating colour the axis-cylinder stands out sharply defined as a dark line on a colourless ground.—*The Medical Press.*

The Proper Angle for the Razor in Paraffin Sectioning.—In the discussion between Dr. M. Heidenhain and Dr. B. Rawitz, relative to section cutting and the staining of microscopic preparations, the latter person* upholds the advice that he gives, in his *Leitfaden*, and adduces experimental proof to show that the microtome knife should be placed at an acute angle to the stroke rather than at a right angle. When placed at the latter angle, the sections, according to their thickness, are always more or less crowded together, thus distorting the finer structures of the tissue cut. The experimental proof consists of the measurement of sections cut with the knife at a right angle, and with it at an angle of 45°. The sections were from a block of paraffin measuring $20\frac{1}{2}$ by $11\frac{1}{2}$ mm., and had a thickness of 15μ, 10μ, and 5μ. With

* "Bemerkungen über Mikrotomaschneiden und über das Föben Mikroskopischer Präparate."—*Anat. Anz.*, xiii., pp. 65—80.

the knife at the acute angle they all measured 11 mm. in breadth, while with the knife at right angle they measured 9½ mm. for the 15μ, 9 mm. for the 10μ, and 8 mm. for the 5μ sections, thus showing a shrinkage of 2, 2½, and 3 mm. respectively. In the case of the thinnest sections, there is a loss in breadth of almost a third of the surface of the block, and such are somewhat incorrectly denominated "sections." They might be called "Quetschen."

—F. C. Kenyon, in *Amer. Naturalist.*

The Recognition of Diabetes by Examination of the Blood. —That a swift and certain diagnosis of diabetes may be made by the examination of a single droplet of blood will appear strange to most readers, but Bremer shows, in the *Journal der Pharmacie von Elsass-Lothringen*, how this may be effected by the aid of the microscope, in demonstrating the grape sugar reaction in that vital fluid. He says :—

"Mix equal volumes of saturated solutions of eosin and methylene-blue, and pour the mixture on a filter as soon as the precipitate ceases to fall. Collect the precipitate, after washing on the filter, dry it carefully, and pulverise it very finely. To this powder add 24 parts of eosin, and 6 parts of methylene-blue, also in fine powder. This will make a reddish-brown powder.

The blood to be examined is spread in a very thin layer over a cover-glass, another cover-glass being smeared with a drop from some person known to be healthy, the latter serving for purposes of comparison.

After drying, put the two cover-glasses simultaneously in a mixture of alcohol and ether in equal parts, put over the water-bath, and let boil for four minutes. Remove and put into a solution made by dissolving from 25 mgm. to 5 cgm. of the mixed powder described above, in 10 gm. of 33 per cent. alcohol (alcohol 1 part, distilled water 2 parts). This solution, we should remark, should be freshly prepared on each occasion that it is required.

Leave the covers in the stain for about four minutes, remove, rinse with water, and examine under the microscope. If diabetes be present in the person whose blood is under examination, the latter will be coloured a blue black, while normal blood takes on

a red violet. In all cases, where possible, for the sake of absolute certainty, the urine should be tested for glucose by any of the well-known reactions."—*National Druggist.*

Fixer for Vegetable Tissues.—Zenker uses the following liquid in the fixation of vegetable tissues for microscopical examination:

Mercury Bichloride ...	10 parts.
Potassium bichromate	5 ,,
Sodium sulphate	2 ,,
Salicylic acid, in crystals	10 ,,
Distilled water	200 ,,

The liquid penetrates and fixes the tissue with great rapidity and sureness.—*National Druggist.*

Separation of Diatoms, etc., from Sand.—The *Zeitschrift für Angewandie Mikroskopie* says :—" For this purpose we use certain liquids of high specific gravity, such as are used in mineralogical operations, and we commend the following :—

BROWN'S LIQUID.—Methylene iodide, which has a specific gravity of 3·3. By adding iodoform to this, this figure is raised to 3·45, while iodine increases it to 3·65.

KLEIN'S LIQUID.—Potassium-boro-wolfranin, the specific gravity of which is 3·28.

ROHRBACH'S LIQUID.—Barium-mercury-iodide, s.g. 3·58.

TOULET'S LIQUID.—Sodium-mercury-iodide, s.g. 3·19.

Other liquids are :—Silver iodide dissolved in a concentrated solution of silver nitrate, which makes an oily, brown liquid of s.g. 5·0; thallium-silver nitrate, melting at 75°C., s.g. 4·1. Concerning this last-named chemical, the *Bayerische Industrie und Gewerbeblatt* has the following information :—

" The specific gravity and the melting point of thallium-silver nitrate fall as the proportion of thallium nitrate is increased; thus, while the latter substance has a specific gravity of 5·00, and a melting point of 250°, the addition of 1 part of silver nitrate to 4 parts of the thallium salt decreases the melting point to 200°C., and the specific gravity to 4·9. Three parts of silver nitrate to 4 parts of thallium nitrate bring the specific gravity down to 4·7, and the melting point to 100°C.

All the above are soluble in, or miscible with water in every proportion. In using them the material is thrown on the liquid, and floats or sinks according to its specific gravity.—*National Druggist.*

The Action of the X-Rays on Micro. Organisms.—Minck * exposed several agar plates which were inoculated with Eberth's bacillus to the action of the X-rays. The time of exposure was half-an-hour. The plate was put into the incubator at the same time as two others which were used as "tests." At the end of fourteen hours there was no difference in the number of colonies that had grown on the three plates.

In another experiment the quantity of culture sown on the agar was less abundant, and the duration of the exposition was thirty-five minutes. The colonies which developed on the plates submitted to the rays were less abundant and thinner than on the test plates. This led Minck to believe that the duration of exposure was too short. Other plates prepared in the same manner were submitted during a period of from two to eight hours to the rays, and were then placed in the incubator. After fifteen hours there was no difference in the aspect or the number of colonies which had grown on the plates.

These experiments seem to prove that the X-rays have no special action on the bacilli, which excludes the idea of using them as a therapeutic agent, at least in infectious diseases. Similar negative results have been obtained by F. Barton, who submitted the diphtheria bacilli to the action of the rays for sixteen, thirty-two, and sixty-four hours. The vitality and the virulence of the bacilli remained in their integrity.—*Bulletin of the Pasteur Institute*, 1897.

Diphtheria Bacilli can be very successfully cultivated upon a new medium recommended by Kanthack and Stephens, in *Centralblatt für Bakteriologie*, May 8, 1896. It is simple, inexpensive, transparent. It resists the development of staphylococci and the colon bacillus surprisingly well; and yet it surpasses all other media for the rapid cultivation and isolation of the diphtheria

* *Munch. Med. Wochenschrift*, p. 202, 1896.

bacillus. For the preparation of this culture medium very fresh ascitic, pleuritic, or other exudative serum is employed, to every cubic centimetre of which two cubic centimetres of ten per cent. caustic potash solution is added, so as to convert the serum albumin into an alkaline form that remains soluble on sterilisation by heat. To this is added agar (one and a-half to two per cent.) that has been softened previously in acidulated water. The mixture is steamed till the agar is completely dissolved. The whole is then transparent, and filters readily through coarse paper (in a hot funnel). Then four or five per cent. of glycerine is added, and also a half to two per cent. of grape sugar, if desired.

Then it is poured into tubes, and allowed to solidify after steam sterilising. It is well to test the serous exudation employed, by boiling a little in a test tube before adding the agar. If this serous fluid then coagulate, because of an unusual excess of albumin, there should be added at least its bulk of distilled water, and the diluted serum then treated as above indicated.—*New York Med. Journal.*

Staining Actinomyces.—Marpmann contributes an article on this subject to the *Zutschrift für Angewandie Mikroskopie*, from which we (*National Druggist*) extract as follows :—The sections (which should be cut from the most infected tissues) are placed first in absolute alcohol, and after this into the following mixture :

Concentrated alcoholic solution of methyl-violet	...	1 part.
Water	...	2 parts.
One per cent. solution of sodium carbonate	...	2 ,,

Leave in the stain for ten minutes, then rinse in water, and put into an alcoholic solution of fluorescein, which contains a small proportion of erythrosin. Here let them remain fifteen minutes, than wash them off in absolute alcohol. Clear in the usual manner with xylol and lavender oil, and mount in balsam. The actinomyces will show up blue.

New Double Stain for Bacteriological Purposes.—For the more certain determination of the micro-organisms in pus, mucus, etc., Pick and Jacobsohn (in the *Berliner Klinische Wochenschrift*) describe a process which for simplicity and certainty leaves little to be desired, and is as follows :—

First make a solution of 1 gm. of fuchsin in 100 ccm. of a 5 per cent. aqueous solution of crystallised carbolic acid, adding 10 ccm. of absolute alcohol thereto. Of this add 15 drops, drop by drop, to 20 ccm. of distilled water. To this add 8 drops of a concentrated (saturated) solution of methylene blue and shake well.

The preparation, smeared on a cover-glass and dried, is floated on this liquid for a few seconds, not less than eight or more than ten, and is then rinsed with plenty of water. It is now ready for examination under the microscope, in either water or glycerine. All of the protoplasm, mucus, and necrotic cell elements, etc., will appear stained a light red, while the fermentive organisms will appear a deep blue and sharply defined, and the cell nuclei a light blue, frequently tinged with red.

Preparations made in this manner, afterwards cleared and mounted in balsam or dammar, if kept in the dark, will preserve their colour for a very long time, but soon fade if exposed to the light. The stain should be kept not longer than a week, as it begins to disintegrate after the expiration of eight or ten days. The two solutions kept apart, however, remain indefinitely unchanged. This process we have found to be especially adapted to the detection and demonstration of *Gonococcus Neiser*.-*National Druggist.*

New Stain for Differentiating the Bacterium Coli and Eberth's Bacillus.—Ramond* has produced a stain with "rubine acid," which stains the bacterium coli red very rapidly, while it does not colour typhoid colonies. It is prepared by colouring a tube of lactosed gelatin or gelose at four per cent., with a few grains of "rubine acid." It is then decolourised by adding, while warm, two drops of saturated solution of carbonate of soda. It is then filtered and sterilised. It replaces Elsner's gelatin advantageously, and owing to its extreme alkalinisation is not favourable to the growth of other kinds of microbes.—*Journ. Amer. Med. Assocn.*

* *Bulletin Med.*, Nov. 11th, 1896.

Natural History Notes.

Multiplication of Ophioglossum.—It results from the observation of Mr. G. Poirault that the Adder's Tongue Fern (*Ophioglossum*) is never reproduced from its spores, but that it is propagated exclusively by buds that form on its roots.

Effects of Cold upon Animals.—In a paper read to the French Academy of Sciences, M. Colin discusses the action of cold on animals. The rabbit endures considerable cold. Adults have lived in ordinary hutches suspended from the branch of a tree or standing on a heap of snow, and their temperature has only been lowered about one degree in five or six days, when the outside temperature varied from 10° to 25° C. Sheep and pigs are also able to live through severe weather, but the dog and horse are killed by it.

Pliny and the Ants of North America.—In Pliny we find the following passage in regard to a certain species of ant :—"Among the Northern Indians, called Dowdes, there are certain ants that *extract gold from the mines*. . . . This metal, which they extract in winter, the Indians rob them of in summer, while the ants are hidden in their tunnels because of the heat."

This passage having struck us by its clearness, says M. Vercoutre (in *Revue Scientifique*), we have been led to ascertain whether the assertions of Pliny are accurate, and, if so, what were the ants that he had heard spoken of. Now, we have found that there exists a particular species of ant that engages in this sort of mining, and that it is the *Pagonomyrmex occidentalis* studied by the Rev. H. C. McCook.

These ants, in fact, after they have finished the hillock that serves as a dome to their galleries, cover the whole with a sort of mosaic work formed of fragments of rock, fossils, ores, etc., which they obtain through a regular mining operation at a considerable distance beneath the surface of the earth. As in the country where these ants are met with it happens that the subsoil is often an auriferous deposit, it will be conceived that the roofing of the ant-hills is frequently composed of spangles of gold, which, washed by the rains of winter, are in the fine season easily recognised and

collected by the aborigines, who thus evidently profit by the labours of the ants.

The fact mentioned by Pliny is therefore absolutely correct; but what is very curious is that but a single species of ant (the one mentioned above) engages in this peculiar labour, and that this ant *is found only in North America* (Colorado, New Mexico, etc.). Hence the dilemma. Either *Pogonomyrmex occidentalis* in the time of Pliny inhabited the Indies properly so called (Hindostan), from whence it has entirely disappeared since that epoch, since it is very certain that it is not found there at present; or else it always inhabited North America solely, and then Pliny's narrative, too precise to have been manufactured, would necessarily have been derived from travellers that had already visited America at that remote epoch.

The first hypothesis seems to us inacceptable, for, although it is true that certain species of ants (such as *Atta septentrionalis*) seem to be on the road to degeneracy, it can be asserted that ants are in no wise creatures whose species can *totally* disappear from a continent in a few centuries; and if, consequently, we must admit the second hypothesis (which would make the "Northern Indians," vaguely mentioned by Pliny, to be "North Americans"), we must see therein a very unexpected argument, which we offer in support of the opinion that the ancients were acquainted with certain parts of America.—*Scientific American.*

Reviews.

A Course of Practical Histology. By Edward Albert Schafer, LL.D., F.R.S., etc. Second edition. Large cr. 8vo, pp. xi.—298. (London: Smith, Elder, and Co. 1897.) Price 7/6.

In this useful book intelligible directions are given for the suitable preparation of the animal tissues intended either for immediate study or future reference. The author has taken care to select methods upon which, in his experience, complete reliance can be placed.

In an Introductory chapter an account is given of the several parts of the microscope, and the purposes for which they are intended, and of the instruments and methods of staining and otherwise preparing tissues which are in more general use in Histology. Instructions are also given for measuring and for delineating microscopic objects. There are a number of good illustrations. We feel that we can confidently recommend it to all working microscopists.

AIDS TO THE STUDY OF BACTERIOLOGY. By T. H. Pearmain and C. G. Moor, M.A. 12mo, pp. 159. (London: Bailliere, Tindall, and Cox.) Price 3/-

The various sections into which this book is divided treat of the Apparatus used in Bacteriological Research; Preparation of Nutrient Media; Methods employed; Characters of the Chief Pathogenic Organisms; Micro-Organisms other than Bacteria; Fermentation, etc.; Bacteriological Examination of Water, etc. etc.

THROUGH A POCKET-LENS. By Henry Scherren, F.Z.S. Cr. 8vo, pp. 192. (London: The Religious Tract Society. 1897.) Price 2/6.

The author here points out how much may be seen with an ordinary pocket-lens and with a simple microscope, and endeavours to dispel the far too common idea that no real work can be done unless one has a compound microscope, with a large battery of lenses and an array of accessories.

The subjects treated of are: The Pocket-Lens, Dissecting Microscope, and some simple appliances; Arthropods and their Classes; The Common Water Beetle, Great Water Beetle, and Cocktail Beetle; Cockroaches, Earwigs, Great Green Grasshopper, Water Scorpion, Water Boatman, Corixa; Spiders, Mites, and Myriapods; Crustaceans—Prawns, Shrimps, Mysis, Crabs, Amphipods, and Isopods; Aquatic Insect Larvæ. There are 90 illustrations.

THE YOUNG BEETLE-COLLECTOR'S HANDBOOK. By Dr. E. Hofmann; with an Introduction by W. Egmont Kirby, M.D. Cr. 8vo, pp. viii.—178. (London: Swan Sonnenschien and Co. 1897.) Price 4/6.

We have seen no better book for the young beetle-collector than this. It contains 20 coloured plates comprising over 500 figures. Besides a general and thorough description of all the various genera and species, we find chapters on the Structure, Development, and Habits of Beetles; How to Kill Them; and How to Arrange the Collection. The plates are beautifully coloured and the collector will have no difficulty in identifying his captures.

HANDBOOK TO THE LEPIDOPTERA, Vols. IV. and V.; being Moths, Parts 2 and 3. By W. F. Kirby, F.L.S., F.Ent.S., etc. Crown 8vo, pp. xlii.—246 and xii.—332. (London: W. H. Allen & Co. 1897.) 6/- each.

These two volumes complete the series on the order *Lepidoptera*. Vol. IV. describes the families *Sphingidæ*, *Bombycidæ*, *Brahmæidæ*, *Drepanulidæ*, *Ceratocampyidæs*, *Saturniidæ*, *Lasiocampidæ*, *Megalopygidæ*, *Eupteroptidæ*, *Pinaridæ*, *Zeuzeridæ*, *Arbelidæ*, and *Hepialidæ*. Vol. V. contains descriptions of the *Noctuæ* and *Geometræ* among the larger moths, and the *Micro-Lepidoptera*. Of these latter, which probably exceed the *Macro-Lepidoptera* in numbers, it has been found impossible to do more than describe and figure a selection of species belonging to the various families. In these two volumes there are 63 good coloured plates.

A HANDBOOK TO THE BIRDS OF GREAT BRITAIN. By R. Bowdler Sharpe, L.L.D. Vol. IV. Crown 8vo, pp. xviii.—312. (London: W. H. Allen and Co. 1897.) Price 6/-

This volume of *Allen's Naturalist's Library* concludes the section devoted to British Birds. It, like all others of the series, is illustrated with a number of excellent coloured plates (31 in the present volume) besides a few engravings in the text.

FLOWERING PLANTS. By Mrs. Arthur Bell (N. D'Anvers). Post 8vo, pp. 204. (London: Geo. Philip and Son.) Price 2/-

This is Vol. VIII. of Messrs. Philip and Son's series of *Science Ladders*,

and, although complete in itself, is really a continuation of Vol. VII., entitled "Vegetable Life in its Lowest Forms," as it takes up the story of Plant Life where the former volume laid it down. The two books, taken together, give a general summary of the laws governing all vegetable life, with examples of the various forms assumed by plants, from the lowly invisible fungus to the stately oak. The illustrations, of which there are 53, are chiefly from photographs taken direct from nature.

DIE NATURLICHEN PLANZENFAMILIEN. By A. Engler. Nos. 140 to 145, and 149 to 152. (Leipzig: Wilhelm Engelmann. London: Williams and Norgate. 1896-7.)

These parts contain accounts and descriptions of the Labiatæ, by J. Briquet; Fucaceæ, Dictojotaceæ, by F. R. Kjellman; Rhodophyceæ, by F. Schmitz and P. Hauptfleisch; Bangiaceæ, Rhodochæctaceæ, Compæopogonaceæ, Thoreaceæ, by F. Schmitz; Lemaneaceæ, Helminthocladiaceæ, Chaetangiaceæ, Gelidiaceæ, Acrotylaceæ, Gigartinaceæ, Rhodophyllidaceæ, Sphaerococcaceæ, Rhodymeniaceæ, Delesseriaceæ, Bonnemaisoniaceæ, by F. Schmitz and P. Hauptfleisch; Rhodomelaceæ, by F. Schmitz and P. Falkenberg; Pyrenomycetineæ, Perisporiales, Hypocreales, Dothideales, Sphæriales, by G. Lindau; and *Peridiniales* and *Bacillariales*, by F. Schutt.

These parts contain 405 illustrations, composed of 1385 figures. All the illustrations are excellent.

BY VOCAL WOODS AND WATERS: Studies from Nature. By Edward Step. Cr. 8vo, pp. 254. (London: Bliss, Sands, and Co.) 2/6.

Mr. Step is a charming writer, and the twenty-two chapters of the book before us are written in a most interesting manner. These chapters treat of The Sea, Life on an Old Wall, Vegetable Vagrants, A Wasp's Nest, Toads, Vegetable Monsters, and a host of others. It is nicely illustrated.

BIRDS OF OUR ISLANDS. By F. A. Fulcher. Crown 8vo, pp. 368. (London: A. Melrose.)

Bird lovers will find much to interest them here. The book is not, and does not pretend to be, an exhaustive treatise on bird life; but the twenty-six chapters into which the book is divided treat the subject in a most interesting manner, and there are 98 very good illustrations.

THE MIGRATION OF BIRDS: An Attempt to Reduce Avine Season-Flight to Law. By Charles Dixon. Amended edition. 8vo, pp. xix.—426. (London: Horace Cox. 1897.)

To the genuine lover of birds there is no more fascinating pursuit than to watch the comings and goings of his favourites, whilst to the more scientific ornithologist Migration is not only an intensely interesting proceeding, but a function fraught with importance in the history of bird life.

The vol. before us embodies the result of sixteen or seventeen years' diligent study and research, as well as close application and thought. The various chapters treat of The Law of General Distribution; Ancient and Modern Views of Migration; The Cause, Philosophy, and Routes of Migration; Migration in the Southern Hemisphere, Internal Migration, and Local Movements; Nomadic Migration; The Perils of Migration; The Destinations of the Migrants; Spring and Autumn Migration of Birds. This new edition has been entirely re-written in accordance with the author's latest discoveries and views respecting the subject of Bird Dispersal.

A NEW ENGLISH DICTIONARY on Historical Principles, founded mainly on the materials collected by the Philological Society. Edited by James A. Murray, with the assistance of many Scholars and Men of Science.

Vol. III.—Distrustfully—Doom. | Vol. IV.—Flexuosity—Foister.

(Oxford: The Clarendon Press. London: H. Froude. April, 1897.) Price 2/6 each part.

The first of these two parts contains 1141 main words, 183 combinations, and 156 subordinate entries. Of these 1141 main words, 896 are current and native or fully naturalised, 203 are marked as *obsolete*, and 42 as *alien* or not fully naturalised. In this section the word DOG occurs, which, with its multitudinous family, occupies 22 columns; also the word DO—to the lexicographer perhaps the most formidable word in the language—occupies 16 columns, and is illustrated by 900 quotations. The etymological part of the article contains a history of this verb to be obtained nowhere else in English.

The Vol. IV. section contains 1025 main words, 350 combinations, and 143 subordinate entries—1518 in all. Of the 1025 main words, 839 are current and native or fully naturalised, 173 are marked as *obsolete*, and 13 as *alien*.

This part includes a more than ordinarily large number of new etymological suggestions, which, it is hoped, will commend themselves to the judgment of scholars.

FIRST-STAGE MECHANICS OF FLUIDS. By G. H. Bryan, Sc.D., F.R.S., and F. Rosenberg, M.A. Cr. 8vo, pp. viii.—208. (London: W. B. Clive.) Price 2/-

The first nine chapters of this book consist of that portion of Dynamics which is also required by the corresponding syllabus in the Mechanics of Solids. This will help the student to attack with success the Hydrostatic portion. Throughout the book the authors have insisted upon examples being worked out from first principles, wherever possible, and formulæ have been reduced to a minimum. There are 77 illustrations.

FIRST STAGE OF PHYSIOGRAPHY. By A. M. Davies, A.R.C.S., B.Sc., F.G.S., etc. Cr. 8vo, pp. viii.—238. (London: W. B. Clive.) 2/-

This volume is one of the Organised Science Series of the University Correspondence College Press, and is intended for the Elementary Examination of the Science and Art Department. Chapters 1 to 6 treat of Motion and Energy; The Mechanical Powers; Heat; The Chemistry of the Earth; and Radiation. The next four cover the Astronomical portion. The remaining chapters treat of the Earth's Surface; Atmosphere; Wind and Rain, etc. There are more than 100 illustrations.

FIRST STAGE SOUND, LIGHT, AND HEAT. By John Don, M.A., B.Sc. Crown 8vo, pp. vi.—307. (London: W. B. Clive.) Price 2/-

In this volume of the "Organised Science Series," two distinct objects have been kept in view—first, to present the matter embodied in the Syllabus in a form that can be readily assimilated by pupils who have just passed the standards of the Elementary School; second, to make the explanations of the phenomena so exhaustive that pupils who have mastered the text will experience little difficulty in giving full answers to questions of the kind set at the Examinations of the Science and Art Department. The methods of working Arithmetical Exercises in Light are fully exemplified, and the exercises in Heat can be worked without arithmetical formulæ. There are 160 diagrammatic plates.

TEXT-BOOK OF MAGNETISM AND ELECTRICITY. By R. Wallace Stewart. D.Sc.Lond. Second edition. Cr. 8vo, pp. viii.—344. (London: W. B. Clive.) Price 3/6.

This is Vol. IV. of the "Tutorial Physics," published by the University Correspondence College Press, and is written for the use of candidates for the Matriculation, Intermediate Science, and Preliminary Scientific Examinations of the University of London. In this second edition much new matter has been added, and some of the more interesting facts connected with magnetic induction in iron has been added. There are 160 illustrations and numerous examples.

SPENCER: THE FAERIE QUEENE, Book I, Edited, with Notes and Glossary, by W. H. Hill, M.A.Lond. Crown 8vo, pp. xxiv.—212. (London: W. B. Clive.) Price 2/6.

At the end of this volume of the "University Tutorial Series" are voluminous notes to the several cantos and a glossary.

MATRICULATION CHEMISTRY PAPERS. Cr. 8vo. (London: W. B. Clive.) Price 1/6.

Contains the last 44 papers set at the Matriculation Examination of the University of London, with model answers to the paper of January, 1897.

FORENSIC MEDICINE AND TOXICOLOGY: A Manual for Students. By C. O. Hawthorne, M.B. Second edition. Crown 8vo, pp. 174. (Glasgow: A. Stenhouse. 1897.) Price 4/6.

The recognised facts and principles of Forensic Medicine are here classified and arranged with the object of assisting students in preparing for examination

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DISEASES OF THE EYE: A Manual for Senior Students. By J. Arthur Kempe, F.R.C.S. Cr. 8vo, pp. 56. (Edinburgh: E. and S. Livingstone.) Price 1/6.

Here we find in a somewhat condensed form a compilation of facts bearing upon the more important Diseases of the Eye, with such additional practical points as were deemed by the author as likely to be useful to the student preparing for his final exam.

MINERALOGICAL GEOLOGY: A Synopsis for the Use of Students. By Alexander Johnstone, F.G.S. Cr. 8vo, pp. iii.—194, with 14 plates. (Edinburgh and London: W. and A. K. Johnston. 1897.) 3/6.

This work, which is intended to accompany the Geological Map of the British Isles, originally compiled by Sir Archibald Geikie, LL.D., and revised and extended by Alexander Johnstone, is divided into four sections. The first treats of the Crust of the Earth; the second, the Study of Minerals; third, Concise Notes on Important Minerals, alphabetically arranged; and the fourth, Rocks, etc. The Plates are so arranged as to give a good idea of Palæozoic Fossils; Secondary or Mesozoic; Tertiary or Cainozoic; Quaternary Fossils.

THE STORY OF THE EARTH'S ATMOSPHERE. By Douglas Archibald. Cr. 12mo, pp. 208. (London: G. Newnes, Ltd. 1897.) 1/-

In this interesting little work the author explains the main features of our knowledge of the conditions which prevail in our atmosphere, as they are interpreted by the science of to-day. The various chapters treat in a concise manner The Origin and Height of the Atmosphere: its Nature and Composition, its Pressure and Weight; Temperature; Circulation; Laws; Dew, Fog, and Cloud; Rain, Snow, and Hail; etc. There are 44 illustrations.

THE MULTUM-IN-PARVO ATLAS OF THE WORLD. Fourth edition. Cr. 16mo. (Edinburgh: W. and A. K. Johnston. 1895.) Price 2/6.

A most useful little book, which may be carried in the pocket. It contains 96 double-page maps, with descriptive letterpress, and 125 three-column pages of index.

In addition to the geographic maps are the following:—The Seasons, Solar System, Ocean Currents and River Systems, Annual Isothermal Lines, Winds and Storms, The Varieties of Man, and several others. The maps are clearly engraved and nicely coloured.

YEAR-BOOK OF THE SCIENTIFIC AND LEARNED SOCIETIES of Great Britain and Ireland, comprising Lists of the Papers read during 1896 before Societies engaged in 14 Departments of Research, with the Names of their Authors. 14th annual issue. 8vo, pp. iv.—270. (London: Charles Griffin and Co. 1897.) Price 7/6.

In the first volume of this invaluable work we were given a Review of the History, Organisation, and Conditions of Membership of the various Scientific and Learned Societies of Great Britain and Ireland. The volume before us gives a Chronicle of the Work done by those Societies (as well as by those more recently founded) during the past year. The various Societies whose work is here chronicled are arranged under the following heads, viz.: Science Generally (Societies occupying themselves with several branches of Science, or with Science and Literature Generally); Astronomy, Mathematics, and Physics; Chemistry and Photography; Geography, Geology, and Mineralogy; Biology, including Microscopy and Anthropology; Economic Science and Statistics; Mechanical Science and Architecture; Naval and Military Science; Agriculture and Horticulture; Law; Literature and History; Psychology; Archæology; Medicine.

We consider no public or scientific library complete without a copy of this work.

THE DICTIONARY OF PHOTOGRAPHY for the Amateur and Professional Photographer. By E. J. Wall, F.R.P.S.; revised and brought up to date by Thos. Bolus, F.I.C. Seventh edition. Crown 8vo, pp. ii.—632. (London: Hazell, Watson, and Viney. 1897.) Price 7/6.

Many decided improvements have been made in this new edition. Perhaps one of the most important is the incorporation of the voluminous Appendix, which in the last edition formed nearly one-third of the entire volume. In addition to this we are told that about 150 pp. of new matter and 300 fresh headings and many new diagrams have been added. The book ought to find a place in every photographic studio.

PLATINOTYPE PRINTING: A Simple Book on the Process. By A. Horsley Hinton. Cr. 8vo, pp. 90. (London: Hazell, Viney, & Co. 1897.) Price 1/-

THE PHOTOGRAPHER'S NOTE-BOOK and Constant Companion, containing 250 Practical Hints, Formulæ, Expedients, etc. By Rev. F. C. Lambert, M.A. Crown 8vo, pp. 94. (London: Hazell, Watson, and Viney. 1897.) Price 1/-

These two little books are Nos. 11 and 12 of the "Amateur Photographer's Library." In the first of these the author sets forth very simply the method of Platinotype Printing, and points ont some of its advantages, which, amongst others, are said to be great ease, rapidity, and simplicity. The frontispiece shows an undeveloped and a finished print.

The Note-Book contains, as stated on title-page, 250 notes on almost as

many subjects. In a future edition we would suggest that these be arranged in dictionary order, thus saving the trouble of constantly referring to the Index, which is found at the end of the book.

PHOTO-AQUATINT; or, The Gum-Bichromate Process, with Illustrations; A Practical Treatise on a New Process of Printing in Pigment, especially suitable for pictorial workers. By Alfred Maskell and Robert Demarchy. Cr. 8vo, pp. 55. (London: Hazell, Watson, & Viney. 1897). 1/-

No. 13 of the *Amateur Photographer's Library* describes the process of Photo-Aquatint which is simple of achievement, whilst the results are very artistic, and have found much favour amongst advanced photographers in Paris and other Continental cities as well as in London. Full working instructions of the process are given in this book, which will most probably exercise an important influence upon the future of Pictorial Photography.

THE YEAR-BOOK OF PHOTOGRAPHY and Amateur's Guide. Edited by E. J. Wall, F.R.P.S. (London: *The Photographic News* Office. 1897.) Price 1/-

A bulky volume of 642 pages, of which the Year-Book proper occupies some 450. It contains a large amount of valuable information on every subject interesting to the photographer, whether professional or amateur. It is divided into sections, Section 1 being devoted to Progress and Practice; Section 2, Facts and Formulæ; Section 3, The Photographer's Gazetteer, a Tourist's Companion and Holiday Guide, compiled by the editor, and giving information of all the places, arranged in alphabetical order, which are likely to be of interest to the photographer; Section 4, Winter Work; and Section 5, Novelties of the Year. This is a good shilling's worth.

BRIGHT AND SON'S A B C DESCRIPTIVE PRICED CATALOGUE of the World's Postage Stamps. Second edition. Cr. 8vo, pp. xiii.—543 and pp. iv.—219. (Bournemouth: Bright and Son. London: Simpkin, Marshall, and Co. 1897.) Price 2/6.

The second edition of this useful catalogue is a great improvement on the first. It is divided into two parts—Part I., Adhesives; Part II., Entires—and is thoroughly revised up to date of going to press. The illustrations—which, we believe, are known as process blocks—are decidedly better than those of the first edition, but we think there is yet room for improvement. There is a useful Foreign Money-Table in the beginning of the book.

THE NATURALIST'S DIRECTORY, 1897. Crown 8vo, pp. 102. (London: L. Upcott Gill.) Price 1/-

A useful little book, giving the names and addresses of British and Foreign Naturalists. These are classified under the heads of Zoology, Microscopy, Botany, Geology, and Palæontology; a Naturalist's Trade Directory; List of Societies, Field Clubs, and Museums; Natural Science Magazines; and a List of the principal Works on Natural History published during the year 1896.

SCIENCE PROGRESS: A Quarterly Review of Current Scientific Investigation. (London: The Scientific Press.) Price 3/-, or 10/6 the year post free.

The April part contains the following papers:—On the Physiology of Reproduction in Plants, by H. Marshall Ward, D.Sc., F.R.S.; Condensation and Critical Phenomena (Part 2), by J. P. Kuenen, Ph.D.; A Remarkable Anticipation of Modern Views on Evolution, by E. B. Poulton, M.A., F.E.S.; The Diseases of the Sugar Cane, by C. A. Barber, M.A.; Wind Scorpions—

A Brief Account of the Galeodidæ, by H. M. Bernard, M.A.; The Cell-Membrane, by J. Reynolds Green, Sc.D., F.R.S.; The Coagulation of the Blood (Part 3), by W. D. Halliburton, M.D., F.R.S.; On the Relation between the Form and the Metabolism of the Cell, by Max Verworn, Ph.D.; Appendix; and Review of Books.

Is the Earth a Planet? A study in Physical and Mathematical Geography. By C. Robertson, M.D., M.R.S.G.S. 8vo, pp. viii.—81. (Edinburgh: St. Giles' Printing Co. London: E. Stock. 1897.) Price 2/-.

In the preface to this remarkable book the author tells us that "during a long residence in India his attention was frequently directed to the area of vertical solar rays, and, from facts then observed, he was led to entertain grave doubts regarding the truth of the conventional theory of an immense solar magnitude. Further study showed that the only theory which could give any intelligible explanation of the facts observed was, that the actual size of the sun must correspond to the area of vertical solar rays, which, in itself, seemed reasonable enough, *although it had never occurred to anyone*. A prolonged study of this subject in all its bearings further convinced me that no rational or intelligible explanation of geographical facts could be given under the Copernican theory that the earth is a planet."

He acknowledges that the earth revolves on its own axis, but that, with the exception of this motion, it is stationary in the centre of the universe, and that the sun, whatever be its distance, which he says *is immaterial* so far as his argument goes, is only 32 miles in diameter.

With respect to the diameter of the sun, he says: "The apparent diameter of the sun, as we see it, when measured on the sphere of the heavens by means of a sextant, will be found to be about 32′. . . Now the question to be discussed is whether this apparent diameter of about 32′ of arc represents a real diameter of over 800,000 miles, or, whether it merely represents a real diameter of about 32 geographical miles. The former is the view arrived at by astronomers of the 17th century, and continued to the present day; the latter is, I believe, the view indicated by geographical facts."

We cannot, of course, quote many of the arguments of the author, nor would it be fair to do so; we will, therefore, content ourselves by making one short extract from the last paragraph of Chapter V.:—"It has, therefore, been shown that the theory advanced in Chapter III., namely, that the apparent diameter of the sun—about 32′ of arc—represents a *real diameter* of about 32 geographical miles, *is in perfect agreement* with all geographical facts observed in the phenomena of the seasons, and is also in harmony with the fundamental definitions as well as with the practice of nautical astronomy."

We wonder if the author can, according to his theory, explain an annular eclipse of the sun. The italics in the above notice are ours.

Great Britain and her Queen. By Anne E. Keeling. Second edition, revised and enlarged. Crown 8vo, pp. xi.—244. (London: Chas. H. Kelly. 1897.) Price 2/-

In this nicely illustrated little book we have an interesting account of the chief national events which have occurred during the reign of Her Most Gracious Majesty the Queen. There are upwards of 100 illustrations.

Among the Dark-Haired Race in the Flowery Land. By Samuel B. Drake. Cr. 8vo, pp. 158. (London: The Religious Tract Society. 1897.) Price 2/-

An interesting account is here given of some of the social conditions amid which missionary work is being pursued in China, showing the difficulties

besetting the path of the missionary. Some of the domestic manners of the Chinese are very amusingly described.

HELDAI'S TREASURE: A Tale Illustrating Manners and Customs of Bible Lands. By Frances Hariott Wood. Cr. 8vo, pp. 103. (London: Society for Promoting Christian Knowledge.) Price 1/-

This tale is founded in the neighbourhood of Galilee, and a good idea of the manners and customs of people is here given.

KARMA: A Story of Early Buddhism. By Paul Carns. (Chicago, U.S.A.: The Open Court Publishing Co.)

This is an interesting story giving an idea of certain phases of the Buddhist religion. It was printed in Japan on Japanese paper of a crape-like texture. The coloured illustrations are by Japanese artists. Count Tolstoi has had this tale translated into the Russian language.

WOMAN'S LIFE: An Illustrated Weekly for the Home. Vol. V., Dec., 1896, to March, 1897. 4to, pp. 544. (London: G. Newnes.) 3/-

An illustrated weekly magazine, devoted to matters specially interesting to the ladies—*e.g.*, Dress, Cookery, Fiction, Poetry, etc.

THE UNIVERSITY MAGAZINE and Free Review. Edited by Democritus. June, 1897. (London office: 16 John St., Bedford Row, W.C.) Price 1/- net.

This part contains 112 pages, and comprises Metzsche's Indictment of Christianity; An Ethical Excursion; The Teachings of Thomas Hardy; The Tory Professor; Mr. Gladstone's Latest Post-card; Usury and Thrift; A Specimen of Religious Journalism; In Extremis; The Legitimation League; Nancy; Conventional Literature; New Books.

THE QUEEN'S EMPIRE. (London: Cassell & Co.) Price 6d.

No. 3 of this beautifully illustrated serial has reached us. It consists of 24 fine engravings (size, foolscap folio), showing how the Queen's subjects worship. We are informed that the fourth part will illustrate Work and Workers in the Queen's Empire. This is certainly a grand work.

SCIENCE FOR ALL. Edited by Robert Brown, M.A., Ph.D., F.L.S., F.R.G.S., etc. (London: Cassell and Co.)

The 20th part completes this most instructive periodical, which will form five handsome volumes, with over 1,700 illustrations. With the present part are included Indexes and Titles for the five volumes and a General Index to the series.

EUROPEAN BUTTERFLIES AND MOTHS. (London: Cassell and Co.) Price 6d.

This grand serial is edited by W. F. Kirby, F.L.S., F.E.S., etc. The 38th part has just reached us. The frontispiece shows a number of beautifully coloured moths, together with their special food plants.

CHUMS. (London: Cassell and Co) Price 6d.

This part, with which is given away a 16-page Diamond Jubilee supplement, entitled "British Battles of the Queen's Reign," is, as usual, full of stirring tales such as boys love, besides a number of instructive articles—*e.g.*, "Five Minutes with the Famous," The "How to Make" Column, and many others.

The so-called Jumping Bean of Mexico.

By Jabez Hogg, M.R.C.S., F.R.M.S., etc.

Plates XVI., XVII., XVIII.

No inconsiderable amount of public curiosity was aroused throughout the winter of 1896—97 by the introduction of a somewhat novel vegetable nut from Mexico under the taking name of "the Jumping Bean." This, so-called, "bean" was heralded forth as "one of Nature's scientific wonders," inasmuch as its peculiar movements "contradicted all mechanical laws, as being an enclosed body without external means of leverage, it was able of its own volition to lift itself clear of the ground," and so forth. Moreover, a writer in a widely-circulating paper, in a moment of ecstatic excitement, described their movements in high-flown words as follows :—"I watched their antics with staring eye-balls and a heaving chest. While they danced round the plate on which they were placed, I danced round the table, jump for jump," etc. After a perusal of some few of many like panegyrics which appeared in the press about these wonderful "beans," no one will be surprised to find, on their first appearance at the "World's Fair," Chicago, the nuts were "eagerly snapped up at a dollar apiece."

It is almost needless to say that the whole of the fabulous and sensational statements published at that time about these so-called "jumping-beans" were very wide of the mark. Nevertheless, they were received with so much credulity that all one's friends purchased them and put questions about them. The "bean" was said to be the production of a Mexican tree, the name of which appears to be rather far-fetched—*Carpo-capsa Saltitans*, and which is certainly not the true botanical name of the plant that produces the so-called "bean," recently discovered in a morass half a mile square, in the neighbourhood of Alamos, the fruit of which on ripening falls to the ground and splits up into three equal parts, somewhat triangular in shape, two containing small black seeds

and the third a small *worm*, which when full grown measures about ten or twelve millimetres in length. "The most surprising thing about it is that there is no hole in the outer covering, as there is in the apple or pear, to indicate the way the worm entered the shell."

The above extracts are from a paper furnished to the purchaser of the nut, printed, no doubt, with a view of promoting the sale of this "jumping bean," but which, on the whole, may be said to be purely mythical. In the first place, "the worm" is no worm at all, but simply a maggot of an ordinary type, belonging to the very destructive weevil family. The egg is introduced into the interior of the nut at an early period of growth, and when its outer coat is soft and yielding to the needle-like ovipositor of the female weevil. The finest nut of a cluster is invariably and instinctively selected for the purpose. This she proceeds to penetrate with a microscopical instrument that enables her to bore a hole, which shall, for the time being, not only elude the human eye, but also the keener eye of her many feathered enemies. Moreover, guided by this unerring instinct, she selects a spot which shall avoid injury to the living germ, and thus put a stop to the secretion of the milky pulp of the kernel of the nut, as upon this hangs the hatching of the egg, and the future life and growth of the larva throughout its stage of existence—a naturally short one of about eight or ten days only. Early in March an opening was made in one of the nuts; it was then found to contain a fully developed yellowish maggot, curled up and feigning death. On removing the larva from the nut for closer examination, its darker brown horny—(chitinous)—head was seen to be furnished with a rostrum, two mandibles, rudimentary antennæ, and eyes; the two upper segments of the soft body were provided with two pairs of jointed retractile legs terminating in sharp pointed hooks; the lower segments of the body on either side having five pairs of inconspicuous pro-legs and breathing apertures. In short, the Mexican nut-maggot, in its formation, closely resembles its English congener, save in one particular—that of its curious jactitating movements on being disturbed, and which were the means of attracting so much attention to the insect. This, however, can be very satisfactorily explained; at all events, it is no longer capable

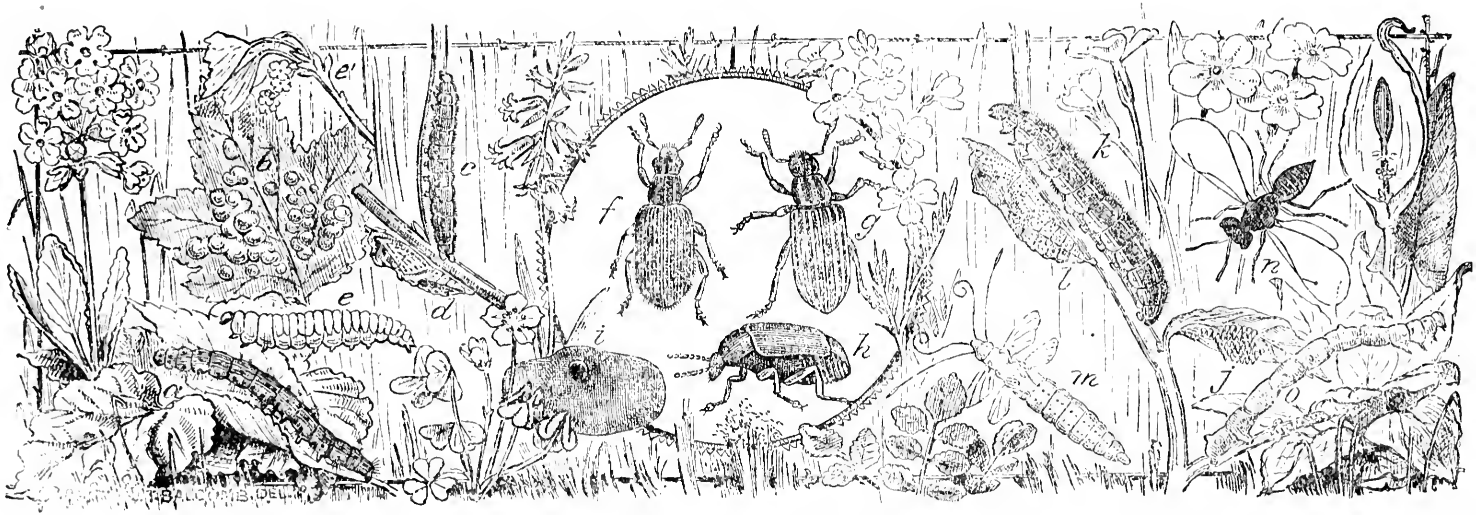
of mystification. The walls of the nut, being thinner than that of the filbert, is parchment-like in texture, and quite permeable to either sunlight or good artificial light. A good table-lamp effectively arouses the maggot from a state of torpor and causes it to make an effort to break through its prison walls. In any struggle to be free, its body is made to assume the form of a ring by simply hooking the rostrum and tail together, thereby placing itself in an extreme condition of elastic tension. Then, on suddenly releasing its hold, its horny head is projected forward with considerable force against the drum-like side of the shell, presumably with the view of breaking through the shell and making a way of escape. The click thereby occasioned may be heard at some distance from the spot on which the nut has been placed. The jump and the action thus brought into play is at once recognised to be interdependent upon the stimulus of light, heat, and muscle, which, when conjoined, are plainly indicative of a rudimentary nervous system, and which, on careful dissection, staining, and the aid of the microscope, is easily made manifest. One's attention cannot fail to be arrested by the wonderful display of nerve-fibres ramifying through an almost transparent structure, and at stated intervals along the sides of the soft body, and which terminate in a ganglia and in a cavity analogous to that of the cranium and brain-substance of the higher organisms. The larva is duly furnished, as some few other species of insects are, with two or more spinnerets. On cutting open a second nut a month later in the spring of the year, a pupa was found enveloped in a fine-spun web; had, in fact, already passed into the pupa stage. On removing this silken covering and the pupa, it was seen to be reduced in length, measuring scarcely eight millimetres, it had assumed a dark-brown metallic hue, and was only awaiting its further and final metamorphosis into that of the perfect insect—the weevil.

It is well known the pupa does not feed, and that life is sustained by the reserve of fat stored up by the maggot. On the other hand, should the maggot fail in its attempts to break out of the nut, it must certainly die in the early spring or summer months; but as the nut would drop from the tree in Mexico upon a wet soil, a morass, the difficulty of breaking through the shell would be considerably diminished. The jumping movements described

have not been observed in either the filbert larva or that of the apple or pear. In this respect it is more than nearly allied to the well-known cheese-hopper, the larva of a fly *(Prophila casei)*, which, on being disturbed in its hiding and feeding place and exposed to light, forthwith proceeds to hook its head and tail together, and then straightening its body out, is seen to bound several inches away, thus quickly escaping its pursuer.

Soon after the "jumping bean" made its appearance in London, a still more curious jumping cocoon from South Africa was brought to the notice of entomologists. This, indeed, rivalled the English cheese-hopper in its fantastic jumping feats. The larva, on being disturbed, quite easily leaped out of a tumbler in which it had been placed. A marked feature in connection with this pupa or chrysalis was that it also is provided with a chisel-like rostrum which it employs, as does the Mexican nut maggot, to cut its way out through the harder porcelain-like coat which envelopes the cocoon. The caterpillar and the weevil tribes are known to be the greatest enemies the gardener and fruit-grower in this country have to contend with. Beans and peas, apples, pears, and nuts have each their characteristic forms of destructive insects. The eggs of beetles, weevils—indeed, of all the insects—hatch out in the early spring, and it is then their great work of destruction is carried on. The food stored up in the cotyledon of a single bean suffices in most cases to carry the larvæ through its first short stage of existence.

The larva of the apple-blossom commits incredible damage in the pear and apple orchards, in France in particular, so much so that syndicates of defence have been formed for its destruction. This weevil is very small, and thereby escapes observation. It is only the fourth of an inch long. It is reddish brown in colour, and is furnished with a long rostrum. The larva, or maggot, is said to be without feet; but I think there must be some mistake here, as the moment the blossom is touched the larva curls itself up and drops to the ground, or lies concealed as if dead. In the filbert orchards of this country, an enormous amount of damage accrues annually from the nut weevil. As soon as the nut is formed, the female is seen boring through the finest nut of a cluster. Usually only one egg is laid, and her maternal task is



EXPLANATION OF PLATE XVI.

a.—Lackey Moth Caterpillar. Nat. size, $1\frac{1}{2}$ in.

b.—*Galls,* of ***Aphis ribis*** on currant leaf.

c.—Caterpillar of small white Cabbage Butterfly, *Pieris Rapæ.* Nat. size, $1\frac{1}{8}$in.

d.—Chrysalis or pupa stage of same.

e.—Larva of Triple Spit-Moth. Nat. length, 3/8th in. Currant leaf withering, from feeding on stem.

f.—Pea Weevil *(S. crinitus).* Nat. size, 3/16th inch.

g.—Bean Weevil *(S. lineatus),* enlarged.

h.—Bean Beetle *(Bruchus rufimanus).* Nat. size, 3/16th inch.

i.—Bean perforated and destroyed by the same. As soon as the fruit is formed, the beetle issues forth from its winter retreat and attacks it.

j.—Eggs of large white Cabbage Butterfly, *P. brassicæ.*

k.—Caterpillar of same. Nat. size, $1\frac{1}{2}$ inch.

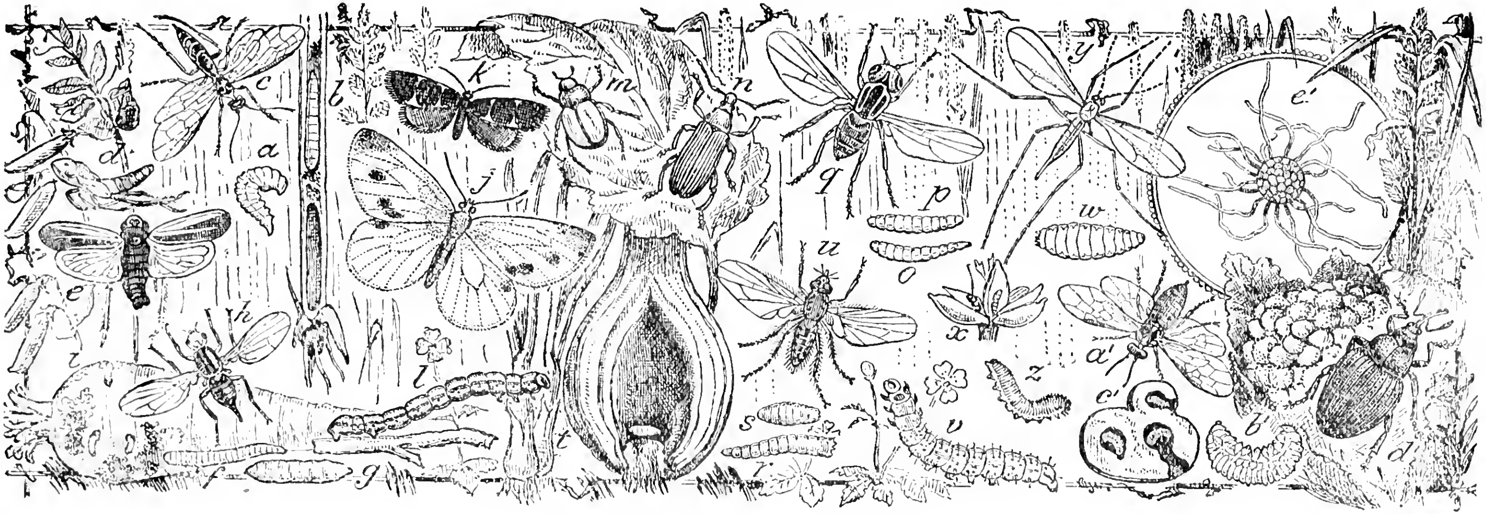
l.—Chrysalis of same. Nat. length, $1\frac{1}{8}$ inch.

m.—Embryo of Cabbage Butterfly. Under surface, showing mask, antennæ, and wings.

n.—Parasite of *Pieris brassicæ,* enlarged, destructive to caterpillar

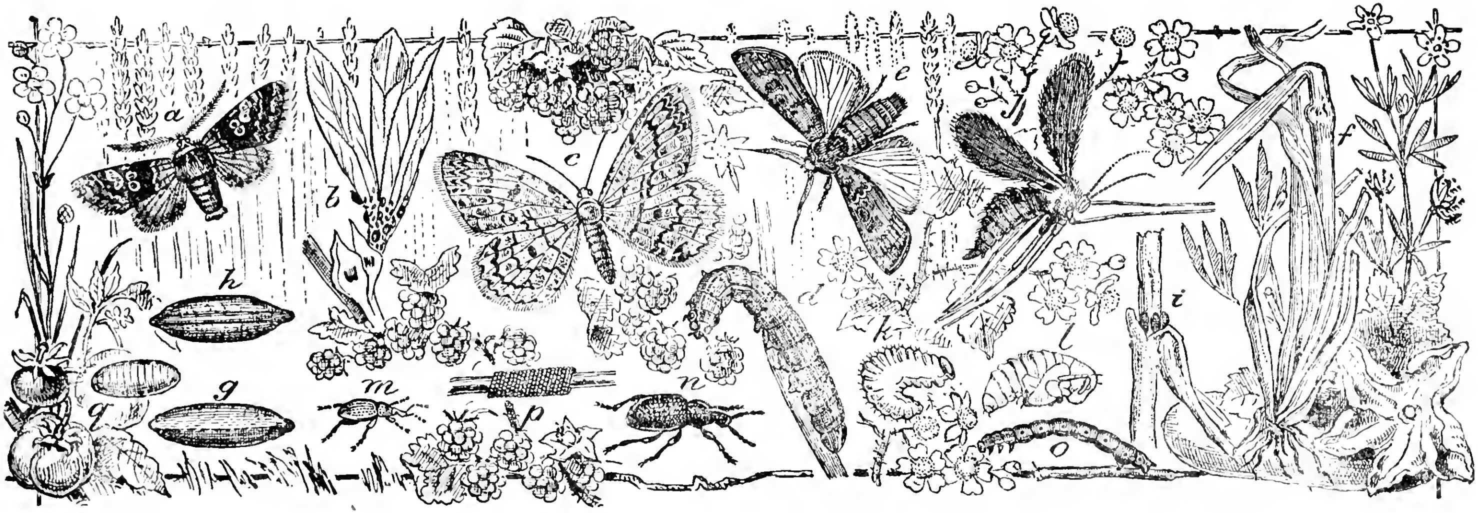
o.—Caterpillar, Oak Beauty Moth.

The names for the most part are indicative of the plants and fruit trees upon which they feed.



EXPLANATION OF PLATE XVII.

a.—Larva of Corn-saw Fly *(Cephus pygmæus)*.
b.—Corn-stalk with larva concealed therein.
c.—Perfect insect.
d.—Frog-fly, or Cuckoo-spit; also known as the Jumper.
e.—Cuckoo-fly, full grown, measuring 8/16th-in. across its wings.
f.—Larva of Carrot-fly.
g.—Pupa of Carrot-fly, somewhat enlarged.
h.—Fly, with wings extended; enlarged.
i.—Carrot infested by larvæ, nat. size.
j.—Cabbage butterfly *(Pieris Rapæ)*.
k.—Triple-spot black moth, life size, the larva of which burrows into the tender shoots of the currant and other fruit-trees.
l.—Caterpillar of Belted-beauty Moth; nat. length, $1\frac{1}{2}$ in.
m.—The June-bug or beetle; feeds on the petals of flowers; nat. size, 3/8th-in.
n.—Leaf-beetle *(Phyllobius maculiornis)*; nat. size, about $\frac{1}{4}$-in. Feeds on the cherry and other fruit-trees.
o.—Larva of Ribbon-footed Corn-fly; nat. length, 5/16th-in.
p.—Pupa of same, enlarged.
q.—Full-grown Corn-fly, measuring across wings 5/16th-in.
r.—Larva of Onion-fly *(Anthomyia ceparum)*; length, 3/8th in.
s.—Pupa of same, enlarged slightly.
t.—Pupa, seen to have bored into a stored-up onion.
u.—Perfect fly; nat. size, $\frac{1}{5}$-in.
v.—Caterpillar of small Ermine Moth; nat. size, 3/8 in.
w.—Larva of Wheat Midge or Red Maggot; nat. length, 1/8-in.
x.—Floret infested by Red Maggot, nat. size.
y.—Perfect fly of same, enlarged.
z.—Caterpillar of Turnip-fly *(Athalia spinarium)*.
a'.—Turnip-fly; natural size, $\frac{1}{2}$ inch.
b'.—Maggot of Turnip Weevil, much enlarged.
c'.—Turnip infested by maggots.
d'.—Turnip-seed Weevil, $\frac{1}{8}$th of an inch long.
e'.—Hop-mould or Mildew, magnified 100 diameters.



EXPLANATION OF PLATE XVIII.

a.—Figure-of-Eight Moth (*Diloba cæruleocephala*). Two-thirds of life size.

b.—Bean Aphis, the Black Dolphin (*Aphis rumicis*).

c.—Pale-oak Beauty Moth (*Boarmia consortaria*), rather smaller than life.

d.—Turnip-moth Caterpillar (*Agrotis segetum*). Nocturnal habits.

e.—Moth of same, reduced in size.

f.—Corn-stem, attacked by larvæ.

g and h.—Pupa-cases of Hessian Fly (*Cecidomyia destructor*). Length, 3/16th inch.

i.—Joint of stem, surrounded by pupa.

j.—The Fly, magnified 6 diam.

k and l.—Pupæ of the Black Weevil (*Otiorhynchus sulcatus*). Very destructive to vines, peaches, and other fruits.

m and n.—Black Weevil Beetles, one-third larger than life.

o.—Caterpillar of Umber Moth (*Hybernia defoliaria*), half life size.

p.—Lackey Moth eggs, laid in a ring round sprig of Pear tree.

q.—Pupa of Beet Fly (*Anthomyia Betæ*).

The plants represented around are many of them poisonous to cattle. For further information see the Annual Reports of the Board of Agriculture, pub. by Eyre & Spottiswoode, London.

finished. The hole made by the ovipositor is extremely minute, and if one is to be seen in the shell it may be regarded as a proof that the tenant has quitted it for good. It has never been observed to jump while enclosed in the nut. Some of the smallest beetles and weevil tribes seem to be the most active of insects. A few jump from the ground, and these are provided with thick hind legs, the femora being straight, and the tibiæ relatively strong and long.

From the great amount of damage done by innumerable injurious insects, it will be apparent to everyone engaged in our fruit-growing districts—the gardener and agriculturist, and, indeed, of every country householder—that it is only by united action (in which our feathered friends should be encouraged to join) the work of destruction will be accomplished. For this reason, the accompanying plates may serve to bring some few of the more destructive weevils and caterpillars to the mind's eye, and the more dangerous among our enemies recognised and destroyed. The subject is one of much interest and importance, and I hope to return to it at no distant date.

Influence of Ether on Plants.—It is reported in the daily press that the United States Consul at Copenhagen has made a report to the Department of State, giving a description of an interesting discovery in the physiology of plants made by Johannsen of the Agricultural High School of Copenhagen. The discovery is that plants are susceptible to the influence of ether or chloroform, but in their case the effect is to awaken them instead of putting them to sleep, as would be the result with human beings. Also, the plants are made to grow with great rapidity in or out of season—a fact of importance to gardeners and florists, providing the statement is correct.

How Plants Live and Work.

By E. Stenhouse, A.R.C.S., B.Sc.

I.—The Daily Life of the Individual.

"THE botanist—nay, I will not say the botanist, but one with even a slight knowledge of that delightful science—when he goes out into the woods, or into one of those fairy forests which we call fields, finds himself welcomed by a glad company of friends, every one with something interesting to tell." So Sir John Lubbock, one of our greatest naturalists, has said. But few of us can aspire to be botanists, yet we may all hope to acquire such a knowledge of plants as shall enable us to experience the great pleasure to which Lubbock refers.

The object of the present paper is to give such an account of the architecture of plants, of the way they breathe, feed, and mate, of their methods of dispersal, as shall enable the most unscientific reader to consider the lilies of the field with the loving apprecia-tion of an intimate friend. There are botanists and botanists. There are those who find a flower, pluck it, rush off to consult friend or "flora," label the wilted weed, for it is now little more, with a couple of awesome polysyllabic words, and straightway shut it up between sheets of paper and squeeze the life-blood out of it with heavy weights. Then they heave a sigh of pleased relief, and are content to know that their herbarium contains another duly labelled "specimen."

Others there are who delight in "double flowers," and all the wondrous varieties which judicious crossing can give rise to. The production of these monstrosities is perhaps a little more praise-worthy than would be the efforts of a farmer to produce by careful breeding a flock of six-legged sheep. Verily, they have their reward. Wordsworth's Peter Bell is the type of another class. Such men are hopeless, and to be pitied.

But the average man is neither a herbarium-filler nor a tulip-fancier; and to him "a primrose by a river's brim" is some-thing more than a yellow primrose. He is peculiarly attracted by the wealth of colouring. The sulphur-tint, which is the predom-inant colour of the petals, the splash of rich, pure yellow at the

centre of the flower, are unique. The delicate contours of the petals rival in beauty the curves of a Greek urn, while the subtle perfume of the flower in its turn appeals to another sense. We feel, in short, that we have here something which is in its way absolutely perfect, and we can understand why Heine, with all his poet's imaginativeness, could find nothing to express admiration and reverence better than "*Du bist wie eine Blume.*" When we remember, too, that the plant is as instinct with life as we ourselves are, that it has to struggle for its existence as keenly as, if less noisily than, we have, our imagination is further kindled. Then, again, why have some Primroses long pistils and others short ones? Why are there Primroses and Cowslips (for it is evident to the most casual observer that they are related)? Why do we so often find associated with Primroses a certain butterfly whose colours exactly match those of the flower? It is to answer these and allied questions, in language free from tedious technicalities, in language "to be understanded of the people," that this article is written.

Get, then, this idea firmly fixed in your minds: plants are alive. This fact, which you, of course, all knew before, may acquire a new significance after a time. Now go out and buy, beg, borrow, or otherwise obtain possession of a bunch of Wallflowers.

Take one of these and examine it carefully and delicately. First, notice the stem. It is green and soft nearest the flowers; further down it becomes brown and harder. It will be seen that there are five ribs running down the stem. On these ribs the lance-head-shaped leaves are inserted. Fix on any one leaf, and the rib from which it springs. The next leaf springs from the next rib, the third leaf from the third rib, and so on. We thus find that the leaves are inserted spirally on the stem, and that every fifth leaf is opposite the same rib. By turning a leaf up it will be seen that its "mid-rib" (the principal "vein") is continuous with the rib on the stem. The mid-rib of the leaf divides and subdivides until the whole blade is supported by a delicate meshwork of so-called veins. The ribs on the stem and the veins of the leaves contain an enormous number of little pipes, by means of which every leaf receives a very efficient water-supply.

The finest of these pipes in the leaves are open at the ends, and thus every cell is bathed in "sap." The word "cell" will be referred to later. All these water-bearing pipes (called vessels) originate in the roots. The main root is a downward continuation of the stem. This "tap-root" branches much in the same way as the stem. The finer branches divide again and again, and the finest branches of all push their way between the particles of soil, seeking assiduously for water. These finest branches are, of course, excessively delicate, and they are protected at their tips by minute caps like tiny thimbles. A little way behind these caps the rootlets are covered by closely set hairs, like very fine velvet pile. These root-hairs take in the water which flows up the pipes. Now, the water in soil is never pure; it contains various salts dissolved in it, and these salts are worked up, mainly in the leaves, into valuable products.

To return to the roots. It was proved in the summer of 1894, by a German botanist, Pfeffer, that there is a very sensitive region just behind the tip of the root. This part acts as the plant's brain, and decides whether it is wise to grow in a certain direction or not. There is something marvellously approaching intelligence in the manner in which a root turns aside from a sharp piece of glass. The absorption of water from the soil is not the only work the root performs. By spreading about in every direction it fixes the plant firmly in the earth. As a matter of fact, absorption takes place only in the very limited regions covered by the fine root-hairs.

So far, then, we have seen that the whole plant is permeated with a fine network of irrigating canals which convey water from the roots up the stem to the leaves. We have next to see what the leaves are for, and to what use they put the water which reaches them from the roots. We have already noticed that the leaves are shaped somewhat like a lance-head. They are flat, and take a more or less horizontal position. Above all, they are green. Now, if we make an exceedingly thin slice across a leaf by means of a very sharp razor, we shall find on examining the slice with a microscope that the whole of its interior, with the exception of the veins, is made up of myriads of minute bodies called cells. In the upper part of the leaf these cells are arranged

regularly, side by side, like three or four rows of bricks, and with their ends pointing towards the middle of the leaf. In the lower half the arrangement is much less regular, and spaces are left between the cells. Each of these cells contains several green bodies called chlorophyll granules. As the life of all green plants, and indirectly even of ourselves, would be impossible without these chlorophyll granules, the introduction of the word chlorophyll, however unfamiliar it may appear, is perhaps excusable. These chlorophyll-containing cells, then, form the packing between the veins of the leaf. Remember that the chlorophyll cells of the lower half of the leaf are loosely set, leaving irregular air-spaces. The whole of this central part of the leaf, chlorophyll-bearing cells and veins, is shut in by a sort of external skin. The air-spaces of the lower part of the leaf communicate with the external air, however, by means of an enormous number of little pores, called stomata. This word is simply Greek for mouths, and is, therefore, very appropriate. Each mouth or stoma has two lips or guard-cells.

This part is perhaps rather uninteresting, but it is necessary for the intelligent consideration of one of the most wonderful and fascinating sides of plant life. As most people know, the air contains a minute proportion of a gas called carbon dioxide. This gas, which is always present, even in the purest air, is made up of carbon (or charcoal) and oxygen. To separate the carbon from the oxygen without employing intense heat would tax the utmost resources of the cleverest of chemists, and yet this is done daily by every healthy green plant in creation, at the ordinary temperature of the air. In the day-time, the air gains access through the mouths or stomata of the leaves to the internal air-chambers I have mentioned above. The chlorophyll-containing cells of the leaf lay hold of the traces of carbon dioxide present in this air, and, by means of energy supplied to them by the sunshine, separate the carbon from the oxygen. They keep the carbon and return the oxygen to the air.

Plants thus purify the air from the poisonous carbon dioxide, and replace the latter by life-giving oxygen. This process can only go on in the presence of sunshine and by means of chlorophyll. Without sunshine chlorophyll cannot put the carbon of

carbon dioxide at the disposal of the plant, and conversely, plants such as Fungi, which have no chlorophyll, are unable, even in sunlight, to separate carbon from the air. Now, starch, sugars, and a host of other useful and indispensable bodies are made up of carbon united with the elements of water. These substances are manufactured in the leaves of plants. There the carbon from the air, and the water which the conducting pipes have brought up from the roots, are united. The details of the process are not understood; possibly they never will be.

We are now in a position to understand why leaves generally take the form of thin, more or less horizontally expanded, plates. It is that each chlorophyll-bearing cell may receive its due allowance of light and air. Hence the cells near the upper surface of the leaf are closely packed, probably because they are nearest the light. The lower cells are loosely packed, and irregular in shape, probably because they have to depend on the light which has filtered through the more fortunate cells above. This economy of space is very characteristic of both plants and animals. It is obvious, too, that the increased surface which results from the shape of the leaf admits of a greater number of stomata and of a corresponding increase in the amount of carbon dioxide supplied to each cell. The one great work of green leaves is the fixation of carbon, and almost every detail of their structure is arranged for the furtherance of this end. Regarded from this point of view, the stem and its branches are to be considered as organs for bearing leaves and spreading them out, so that they shall not interfere with each other's work. The arrangement of the Wallflower's leaves in spirals around the stem has the same object.

We have now rapidly sketched the more essential features of the work done by the root, stem, and leaves of a flowering plant. These must be properly realised if the difficulties, the snares, and pitfalls of plant life are to be sympathetically understood. They constitute the daily routine, "the trivial round, the common task" of plants. But plants, like human beings, have their romance. In Spring they deck themselves in gay colours, and hang out placards for the benefit of bees, and of all others whom it may concern. "Here you may get good honey in return for certain services" is the legend on every brightly coloured petal, and the bees are not slow to take the hint.

What flowers are, and what is their function, what are the services which bee and butterfly come so readily to perform, we shall see later.

II.—The Reproduction of a Flowering Plant.

We have seen that a green plant gets through a tremendous amount of work. The tiniest leaflet at the summit of the highest forest-tree is constantly being supplied with weak watery solutions which the tree has raised, by some mysterious means, from the ground. At the caprice of every breath of wind, the leaflet is yet throughout the day performing chemical operations of the highest degree of complexity and importance. These operations depend upon the activity of the living matter of the tree. Every plant is made up of cells and the products of cells, and every living cell contains a viscid substance called protoplasm, which Huxley, in a happy phrase, termed "the physical basis of life." So far as is known, protoplasm is the only living matter in creation. It is by the activity of the protoplasm of its cells that the plant is able to build up, from air and soil, those complex substances which are so vitally necessary to us.

Now, all this work is, in a sense, purely selfish. It is performed for the benefit of the individual plant, and would of itself soon come to nought. It seems to be an inexorable law of Nature that everything that lives must, sooner or later, die. Why this should be so, is not very clear; but it is evident that if plants are not to become altogether extinct, they must of necessity devote part of their energies to producing new individuals, and to sending them forth into the world as well equipped as possible for the battle of life. It is with this unselfish and self-sacrificing side of a plant's life-work that we must now deal.

Take another Wallflower and examine the blossom closely. There are evidently at least eight leaves in the flower, but, unlike the green "foliage" leaves, these are not arranged spirally on the stem, but are inserted at nearly the same level. The most external leaves are four in number, small, narrow, and purplish in colour. Each of these leaves is called a sepal, and the four sepals together constitute the calyx of the flower. Notice carefully that two opposite sepals are bulged out at the bases, forming pouches,

which contain honey. The position of these honey-glands or nectaries should be remembered. Before the bud opens the calyx is the only part of the flower which is visible. It is probably developed in the Wallflower solely for the protection of the more delicate structures within. Next, inside the sepals, and inserted alternately with them, are four showy leaves, arranged in the form of a Maltese cross. These leaves are called petals, and the four petals together form the corolla.

The petals are delicately scented, and their surfaces have a peculiarly beautiful velvety sheen. The rest of the flower has, at first sight, no resemblance whatever to leaves. If the sepals and petals be carefully removed, it will be seen that there remain six stamens surrounding a centrally placed pistil.

The comparatively insignificant stamens and pistil, strange as it may seem, are the all-important parts of the flower; indeed, it is in order that they may fulfil their functions that all the other parts of the flowers are formed; calyx, corolla, honey-glands, exist only for this purpose, notwithstanding Man's pleasing delusion that the beauty and the scent of flowers, the luscious sweetness of fruits, were created for his especial delectation!

The stamens constitute the fertilising apparatus of the flower, while the pistil produces the young seeds. The stamens may, therefore, be looked upon as the male, and the pistil as the female part of the flower.

To quite understand the work which stamens and pistil perform, it is necessary to examine them in a little more detail. Each stamen consists of a greenish stalk, surmounted by a yellow boat-shaped body, called the anther of the stamen. The anther is a box with four compartments. When it is ripe, each compartment contains an enormous number of tiny yellow grains called pollen grains, and when the anther bursts, as it does as soon as the flower opens, its inner face is covered by the yellow dust of the pollen. The pistil bears a rough resemblance to a slender bottle, and consists of three distinct parts. The neck of the "bottle," called the style, is short in the Wallflower, and differs from an ordinary bottle-neck in being solid instead of tubular. At the top of the neck, where the cork would come in a real bottle, is a body called the stigma. The stigma of the Wallflower pistil is hairy and

slightly sticky from a sugary solution which forms upon it. There still remains the part of the pistil which corresponds to the body of the bottle. This is called the ovary, because in it are formed the ovules or young seeds.

The ovary of the Wallflower is divided into two chambers by a vertical partition, and each chamber contains two rows of ovules running down its length. The structure of the stamens and pistil may seem a little complicated at first, but, in view of the profound interest of the process next to be described, it is well worth while to take a little trouble to master their main features.

We have, then, on the apex of the flower-stalk—after removing sepals and petals—six stamens, each with its terminal pollen-box, and a single central pistil consisting of stigma, style, and a basal ovary or ovule-box. In order that fertilisation may be effected, and a new plant formed, the contents of a pollen grain must come in contact with the contents of an ovule, and all the details of the flower's structure are arranged to secure the fusion of the two. The delicious scent and brilliant colouring of the petals, and the honey inside the sepals, are formed solely with this object in view. A necessary preliminary to fertilisation is that the pollen shall gain access to the stigma of the pistil. It can easily be proved by an interesting experiment that, unless this takes place, the ovules will never become seeds capable of growing into new plants. To show this, it is only necessary to remove the stamens from a flower before their pollen has had any chance of reaching the stigma. As the anthers of the stamens burst as soon as the flower opens, the flower must be opened artificially in order to remove the stamens in time. With a little care the operation may be performed so as not to otherwise injure the flower. If now the plant be covered by gauze to preclude the possibility of pollen being brought by insects, it will be found that the flower will wither without forming ripe seeds. That this effect is entirely due to the absence of pollen may easily be shown by transferring a little pollen (by means of a fine brush) from another flower to the stigma of the one under experiment. If this be done, the seeds will ripen in a perfectly healthy and normal manner.

It is quite clear, therefore, that the problem each flower has to solve is—to contrive a means by which the stigma of its pistil

shall obtain a due supply of pollen grains, either from its own stamens or from those of some other flower of the same species. It has been conclusively proved by various botanists—more particularly Darwin, Sprengel, and H. Müller—that a flower produces more, and also better, seed when it is fertilised by pollen from another flower. Such cross-fertilisation is chiefly performed by insects, and, as we shall see later, some flowers have adopted devices, which are perfect marvels of ingenuity. for bringing about this object. The inducements offered by the Wallflower to bees are not of a very complicated or subtle character, but they are quite effective.

A bee comes to a Wallflower for the sake both of honey and pollen, the "bee-bread." As the bee thrusts its proboscis down between stamens and pistil in search of the honey in the sepal pouches, its head is pretty certain to come in contact with, and to brush off, some of the pollen-dust which is hanging loose on the inner faces of the anthers, for we have seen that the anthers of the Wallflowers burst on their inner sides. When the bee flies off to another flower and continues its search for honey, it almost invariably leaves some of the pollen from the first upon the hairy stigma of the second.

Flower and bee are thus mutually helpful. The flower provides the bee with "bee-bread" and honey, and in order to make the insect's search easier it displays gaily coloured and attractively scented petals, actually marking them in some cases with lines which guide the animal to the nectaries. The nectaries, however, are placed in such a position that before the bee can reach the honey, it must perform the service of transferring pollen to the stigma. It is still possible that some few Wallflowers may not be visited by insects. In order to provide for such a contingency, the anthers of the four inner stamens grow up so as to overhang the stigma, and some of their pollen drops on it. This self-fertilisation is not so good as the cross-fertilisation brought about by the visits of insects, but it is much better than nothing.

The first great essential is now *un fait accompli.* The pollen has gained access to the stigma of the pistil. As has been mentioned above, the top of the stigma is sticky with a sugary solution. This sugary solution stimulates the pollen grains to

growth, and each pushes out a long tube which grows down between the cells of the style, the "neck" of the bottle-like pistil.

The living protoplasm of the grains grows out into the pollen tubes, and keeps near the tips of the tubes as these continue their journey down the style. At length the tubes enter the ovary and find the ovules. Each ovule has at one end a minute pore, and marvellously enough the pollen tubes "make" straight for the pores and enter them. How they find their way with such unerring accuracy we do not at present know. The protoplasm of the pollen tube fuses with that of the ovule in the neighbourhood of the pore, and fertilisation is effected.

The whole process is beautiful in the extreme, but its ultimate *rationale* is still one of Nature's secrets. This, however, seems to be clear; a cell in itself sooner or later attains a state of senility, notwithstanding the mysterious power of its living protoplasm to make fresh living matter from dead food. This state of senile decay can, however, be indefinitely postponed by fusion with living protoplasm from another individual. Hence, while an ovule of itself is doomed to ultimate death, the union of its protoplasm with that of a pollen grain stimulates it to renewed activity, and actually gives it the power of dividing and subdividing until it forms a new plant with all the powers of its parent.

Reproduction is an expensive process for the plant, yet without this process all plants would very shortly be extinct. Hence each must periodically put aside the question of its own individual welfare, and devote itself to serious work for others.

And it is precisely those races of plants which make the largest sacrifices to secure the well-being of their offspring, which attain to the highest positions in the world. We shall see that the lowest plants have the most primitive methods of multiplication, and in most cases make only the very smallest provision for their young.

While the process of fertilisation described above for the Wallflower is in all essential particulars similar to that adopted by other flowering plants, the mechanism for securing cross-fertilisation used by various other wild flowers is very complex, and often startlingly ingenious.

III.—Fertilisation Devices.

We have seen that, wonderful as is the life-work of the roots, the stem, and the leaves of a flowering plant, that of the flowers themselves is much more so. We have traced out in its very broadest outlines the work done by sepals, petals, stamens, and pistil in the Wallflower, and have found that each part of the blossom has a definite duty allotted to it. The calyx protects the flower-bud, and, when the bud has opened, forms pockets for the storage of honey. The corolla, by its odour, and by hanging out gaily coloured placards, advertises the presence of the honey. The stamens produce fertilising pollen, and the pistil contains fertilisable ovules. The relative positions of these parts render it practically certain that in obtaining the honey the bee must become dusted with pollen in those parts of its body which are likely to come in contact with the sticky stigma of the next Wallflower visited. In those flowers whose ovules are contained in ovaries, the access of pollen to the stigma must take place before fertilisation can be effected. Nature has adopted all sorts of wonderful devices to secure that the ovules shall be fertilised by pollen from different flowers, for "breeding in and in" is as ruinous among plants as it is in animal life.

We must now deal with the most noteworthy of the devices adopted by plants to prevent self-fertilisation. One extremely common method is to have stamens and pistils on different flowers, and it is immediately obvious that with such an arrangement self-fertilisation is, in the nature of things, an absolute impossibility. It is quite true that such flowers in many cases depart very widely from one's previously conceived idea of what constitutes a flower. If in early Spring we go out into the woods, and fix on an old Oak tree (an Oak hardly ever "fruits" before it is fifty years old), we shall very likely see the flowers on some of the young twigs. The female flowers, one to five on each flower-stalk, are near the end of the twig, while the male flowers arise lower down. Each female flower consists practically of a single pistil, partially enclosed in two envelopes. With the envelopes we need not here trouble ourselves, except to remark that the lower one ultimately becomes the familiar "cup" of the acorn. What more immediately concerns us is the fact that the stigma

has three spreading lobes for receiving pollen. It should also be noticed that each flower-bearing stalk stands well out from the leaves, in order that the foliage shall not interfere with the access of the pollen to the stigmas of the pistils. The male stalks hang down from the lower part of the twig, and every stalk bears about a dozen flowers. The male flowers have each from five to twelve stamens, but they have no ovaries. The stamens produce pollen in the usual way, and when they burst the wind blows the loose pollen from the dangling stamens and scatters it in the air. Some of the fine pollen dust is almost certain to be wafted to the stigmas of the female flowers, and the pollen grains put out their tubes and in due course fertilise the ovules.

Now, although the flowers of the Oak are certainly pretty enough, there is nothing showy about them. They do not go to the trouble of pandering to the taste of bees and butterflies for honey, and hence have no necessity for glaring advertisements. In short, they have no needs for insects, and do not encourage their visits. The gentle breezes of spring render them all the assistance they require for fertilisation. It must not, however, be supposed that the Oak does things "on the cheap." A little consideration will show that a plant which depends on wind-fertilisation must of necessity produce a relatively enormous quantity of pollen in order to ensure that fertilisation shall take place, in spite of the loss of pollen which the method entails.

Most of our forest-trees resemble the Oak in the fact that they are fertilised by the aid of the wind. We can see that for the process to be successful the trees must flower early in the Spring, before the foliage has become thick enough to get in the way of the pollen and prevent it from reaching the stigmas of the female flowers. It is also necessary that the pollen may be easily detached, and it is for this purpose that the male flowers of the Oak and similar trees hang down in the familiar "catkin" fashion.

In the cone-bearing trees—such as the Pine and Spruce Fir—the ovules of the female flowers are naked; that is, they are not enclosed in an ovary, and the consequent absence of a stigma makes a different arrangement necessary. The female cone consists very largely of smooth scales, and the ovules are placed on these scales near their bases. When the pollen falls on the

cone, the grains slide down the smooth scales, and very likely come in contact with the ovules at the bottom. Each ovule has a sticky drop of gum at the end, and the pollen is caught. Such pollen grains as roll off the upper scales are almost certain to fall on a lower one and reach its ovules. The pollen grains of these trees are rendered particularly buoyant by being blown out at the sides into little air-filled bladders. Not all wind-fertilised plants have their male and female organs in separate flowers, however. The Grasses afford a case in point. They have small and (because they do not need to attract insects) insignificant flowers. The stamens hang out loosely to the wind, and as the delicate stem of the plant bends gracefully before every passing breeze the pollen is readily detached and carried away to other flowers. In order to catch the wind-borne pollen grains, the stigmas of Grasses are generally branched and feathery.

It is a practically invariable rule that no wind-fertilised flowers are brightly coloured or conspicuous.

The contrivances of insect-fertilised plants to prevent self-fertilisation are of two chief kinds. In the first of these, the male and the female organs of the flower ripen at different periods. Generally, the stamens come to maturity first, and whilst the pistil is yet undeveloped. A flower in this condition is to all intents and purposes male only. When the stamens have shed their pollen, and, therefore, finished their work, the pistil ripens, and the flower is then female only. Occasionally there is an intermediate period, however, when both sexes are represented together. The second method adopted is for the plant to produce two, or occasionally three, distinct kinds of flowers.

A plant whose flowers afford an excellent example of the first of these devices is *Tropæolum*, which, under the name of "Nasturtium," is so common in our gardens. The honey of the flower is contained in a long tube, the "spur." When the flower first opens, neither the stamens nor the pistil are mature. As the stamens ripen, one by one, the anthers turn up so as to stand in front of the opening of the honey-tube, and a humble bee cannot possibly reach the honey without brushing its breast against the anther and carrying off some of the pollen. When all the pollen is shed the stamens die, and the pistil turns up so that its stigma

now occupies the position in front of the honey-tube. A bee visiting the flower at this stage is certain to leave some pollen on the stigma if it has recently left a flower in the first or male condition. The flower has a series of lines on the petals to guide the insect to the honey-tube, and the lower petals are provided, in addition, with a number of pointed processes which keep the rain out of the spur. Their situation also possibly makes it uncomfortable for the bee to stand in any other position than that which ensures that its breast comes in contact with the anther or stigma.

Only in comparatively few plants do the pistils mature before the anthers, but one of these cases is so extremely interesting that I must mention it. What is generally called the "flower" of the Cuckoo-pint or "lords and ladies," consists of a big curled leaf with a purple rod sticking up in the middle. Near the bottom of the rod, but, hidden from sight by the lower part of the leaf, the blossoms arise. The chamber containing the blossoms is shut in by a series of stiffish hairs which point downwards Below these the rod supports a series of anthers, and, near the bottom of the chamber, a number of pistils. On cutting open the chamber one nearly always finds a lot of midges, covered with pollen which they have brought from another "flower." The midges get in easily enough, but once in they are prisoners, for the down-pointing hairs prevent them from getting out again. The pistils near the bottom of the rod ripen and are fertilised by the pollen the midges have brought. After a time the anthers above ripen, and shed their welcome pollen on the hungry captives. Soon after this, the hairs at the top of the chamber shrivel up, and the midges, once more covered with pollen, are at liberty to return to the outer world, and, untaught by experience, to repeat the experiment on another "flower." Cases where self-fertilisation is prevented by the difference in the times of maturity of stamens and pistils are very numerous, but the examples I have given are sufficient to show how effectual the device is.

Let us now return to our Primrose. In the first section it was asked, "Why have some Primroses long pistils and others short ones?" There are two kinds of Primroses, known to country children as "pin-eyed" and "thrum-eyed" respectively. In a pin-eyed Primrose the pistil is long, and the stigma, looking somewhat like the head of a pin, is at the top of the corolla-tube, while the

stamens are half-way down. Now, the thrum-eyed Primroses have their stamens at the top, while the stigma of the pistil is half-way down the tube, exactly opposite the part where, in the pin-eyed form, the stamens are inserted. This curious state of things was a great puzzle to botanists until Darwin cleared up the mystery. A bee, thrusting its proboscis down a pin-eyed Primrose, would dust it with pollen about half-way down, just in the place which would come in contact with the pistil when the animal visited a thrum-eyed flower. And the pollen from the thrum-eyed form would adhere to the proboscis where this would touch the stigma of a long-styled flower. This beautiful and simple arrangement obviously ensures that each Primrose shall be fertilised by pollen from the other form.

The flowers of the Pea tribe—the Vetches, Clovers, and Brooms—owe their quaint shapes to the visits of insects; indeed, it may be laid down as a general rule that all flowers with irregular corollas are fertilised by insects; and the shape and colours of corolla assumed depend upon the particular predilections of the insect it is desired to entice. Bees and butterflies are very astute critics both of form and colour, and flowers which in these respects do not meet with their approval are left severely alone, to "die unmarried, ere they can behold bright Phœbus in his strength." The Labiates, for example, have their flowers so modified that the lowest part of the corolla forms a platform, on which the bee may conveniently alight, while the upper petals unite into an arched roof, which protects the pistil and stamens. This order is particularly interesting in its relations to insects, and no better example could be taken than that of the Sage. This flower contains four stamens, but two of these have lost their use, and the others are modified in a strange manner. The whole stamen has somewhat the shape of a capital T, and at each end of the cross-piece is a pollen-box. Usually the cross-piece is not at right angles to the stalk, but is swung up (the junction acts like a hinge) until it is nearly vertical. The pollen-box which is at the lower end of the cross-piece when this is vertical contains hardly any pollen. Thus we get the entrance to the honey tube guarded by two pillars, the stalks of the stamens; and the lower pollen-box of the cross-piece of each stamen is directly in front of the bee's

head as it stands on the lower lip of the flower. When it pushes forward its head to reach the honey, it comes in contact with the lower pollen-boxes, and the cross-pieces swing round on their hinges, bringing the upper pollen-boxes down with a smack on the bee's back, and sprinkling it liberally with pollen dust. Having shed their pollen, the stamens shrivel up, and the pistil comes to maturity. As it ripens, the stigma arches over, so as to scrape along the back of any bee visiting the flower for the honey, and thus to wipe off the pollen which has been brought from a younger flower.

The Orchids form another group which has invented a novel and ingenious method of securing cross-fertilisation. The pollen is present in these flowers when ripe as two club-shaped masses. The "handles" of the clubs are connected with a slightly complicated, but exceedingly sticky, arrangement, by which a moth coming to suck the juices of the flower is practically compelled to carry off the pollen masses on its proboscis. When the moth leaves the orchid, these pollen masses have an upward direction, but they soon begin to point forward, because the membrane to which they are attached contracts in a peculiar way. They now project in such a manner that when the moth visits another flower the masses of pollen come in contact with its stigmatic surfaces. These surfaces are also gummy, and tear off some of the packets of pollen of which the "clubs" are composed. A single pair of pollen masses is thus sufficient to fertilise several Orchids. We may readily imitate the whole process by pushing a fine straw, or the point of a pencil, into the flower. The pollen masses stick to the straw, and are removed when this is withdrawn.

It should now be clear that the flowers of such plants as are fertilised by insects are modified in accordance with the habits and structure of their guests. For example, flowers which are fertilised by night-flying moths have no honey-guides, and they generally keep closed, or "sleep," during the day.

The insects, in their turn, have become modified to harmonise with the peculiarities of the flowers they most affect. This change of structure is, as one would suppose, most marked in the mouth-parts and legs of bees and butterflies. Those bees which visit flowers whose honey is at or near the surface have short lower lips,

like those of a wasp. As we examine bees which obtain their honey from deeper and deeper parts of flowers, we find that the lower lip becomes longer and longer, until, in butterflies and moths, the proboscis reaches an astonishing length. There are similar gradations in the development of hairs on the hind legs. In many bees the legs are simply hairy, and the pollen is carried off entangled in the hairs; but the hive-bees work the pollen into a paste with honey, and carry it off on one side of the leg. Further than this, the humble bee has managed to develop a structure on its hind leg which acts as a small basket, in which the little piece of pollen—worked up into a dough with honey—is carried.

IV.—The Life of the Masses.

A student of social conditions would acquire an extremely limited and one-sided view of life if he formed his conclusions solely from observations of a church parade in the height of the London season. If his mental perspective were not to be hopelessly distorted, it would be necessary for him to take into consideration the conditions of life among the great mass of the population, and it would be from such considerations that his soundest views would be formed. Even then his ideas would be merely superficial, and he could only hope to arrive at the true relations of the phenomena of modern life by taking into account the causes to which the phenomena are due—causes which could not be rightly understood and realised except by the study of the history of the race.

So it is with the races of plants. Flowering plants are no doubt the most picturesque, and the gay costumes they assume in the season win the admiration of every lover of beauty. But there is also the rank and file of the plant social system to be considered; the humble beings of whose beauty no poet ever raves, whose very name of "Cryptogams" indicates that their marriage customs are invisible to the unaided eye. Every ditch contains minute plants of exquisite beauty; the woods and hedgerows are covered with decayed aristocrats, who trace their descent from mighty forest kings. Even the flowering plant has to contend against the insidious onslaught of blackmailing parasites. It is mainly from the study of these lower forms that the recent enor-

mous advances in botanical knowledge have been made. And as the historian pores over dusty manuscripts and musty tapestries, as the antiquary weaves a romance of prehistoric man round the chipped piece of flint he picks up on the moor, so the botanist, in the humble Horsetail, sees visions of a far-off age long before the "everlasting hills" of the Pennine Range were raised, when flowering plants had not yet come into existence, and when the swampy land was covered with thick forests of trees which have long ago become extinct.

At the enormously remote period when our coal was being formed, the monarchs of the plant world consisted of what are called Vascular Cryptogams. Of this ancient stock there are now only three surviving families—the Club-mosses, the Ferns, and the Horsetails. As the life-history of these is, speaking broadly, very similar, we may take a Fern as a familiar and fairly representative type. It will not be necessary to enter in any detail into the daily life of an individual Fern, for in all essential respects this corresponds with what we have seen to be the case in our Wallflower. The Fern obtains its mineral food from the soil by means of its roots, and its carbonaceous food from the air by the agency of the chlorophyll granules of its leaves, just in the manner I have already described; but it reproduces its kind in a fashion quite different from the methods in vogue among flowering plants. If we examine the lower side of the leaf or frond of a "Male Fern" (which, by the way, is no more male than female), we shall probably see a number of small, brown, kidney-shaped scales. Each scale is attached to the leaf by a short stalk, and the structure thus bears a rough resemblance to an umbrella. Attached to the bottom of the short "handle" of the "umbrella" by stalks are several tiny boxes, somewhat like pill-boxes. Each box contains when ripe about fifty minute grains, which may thus be likened to the pills of the pill-boxes. These "pills" are called spores. Summing up thus far, we may say then that the spores are formed in spore-boxes, which are attached by stalks to the surface of the frond, each group of spore-boxes being covered by a protective scale. There is a great deal of variation in the way the spore-boxes are arranged on the fronds of different Ferns; for instance, in the Bracken Fern the spore-boxes arise near the

edge of the leaf, and the edge is turned over so as to cover them in. Here the scales are unnecessary, and are therefore not formed.

When the spores are ripe, each box becomes dry, and is ultimately burst by the sudden straightening of a spring which is coiled round its edge. The force of the uncoiling of the spring is sufficient to jerk the spores out of the box into the air, and they may be carried for some distance by the wind before they at length reach the ground. Once there, however, each spore, under favourable conditions, begins to grow, and gives rise to a plant, which, curiously enough, is not in the least like the parent Fern plant which produced the spore. The new plant rejoices in the name of Prothallus. It is important to notice that the spore is produced by a purely non-sexual process. In this respect it differs widely from a seed, which, it will be remembered, results from the union of the protoplasm of a pollen grain with that of an ovule. The Prothallus is a flat, filmy little plant of the form which is generally called heart-shaped. It has neither stem nor roots, but, as its cells contain chlorophyll, and as it puts out on the lower surface little hairs which take up watery solutions from the soil, it is in no danger of starvation, and is quite capable of taking care of itself and leading an independent existence. This tiny plant (the biggest Fern Prothallus I have seen was about the size of a 3d. piece), in contrast with its parent, produces sexual organs. Some of these organs give rise to male cells and others to female cells. The male cells are excessively small, and can only be seen by the high power of a microscope. When they are ripe they swim about in a drop of dew or rain, just like little animals, and find their way to the female cells, which they fertilise. The embryo which results from the union grows up into an ordinary Fern plant. There is thus in Ferns a very sharply marked alternation of generations. The first generation, the ordinary Fern, which is non-sexual, produces, by means of spores, the sexual generation, called a Prothallus. The Prothallus gives rise, in its turn, by a sexual process, to the obvious Fern plant. Each generation, therefore, resembles, not its parent, but its grandparent.

The Horsetails, sadly reduced though they are, and, at least in British species, showing but little evidence of the former glory of

their family, still, like the Ferns and Club-mosses, keep up the ancient traditions of their race and exhibit the characteristic alternation of generations. The plant we know as the Horsetail is the non-sexual generation and it produces a sexual Prothallus, which is amazingly like that of the Ferns. That two plants whose non-sexual generations are so widely different should have practically the same form of Prothallus is very curious and suggestive, and probably indicates that the Prothallus is the primitive form, and that the spore-bearing plant with which we are familiar has become modified to suit its conditions in order that it may be better able to scatter the spores.

In some of the lower Liverworts, the obvious plant itself is very much like the Prothallus of a Fern, and the spore-bearing generation, instead of becoming big and strong like a Fern, remains as an insignificant and partly parasitic form upon the sexual generation. In fact, in all the "moss-like" plants, including the true Mosses and the Liverworts, the spore-bearing generation, instead of growing a stem and leaves like a Fern, is simply an unostentatious "fruit" upon the prominent and often highly developed stage which corresponds to the lowly Prothallus of the Fern and Horsetail. There is thus between the Vascular Cryptogams and the moss-like plants a great gulf fixed. Great as is the gulf, it is as nothing in comparison with the enormous difference which exists between the elaborate and highly specialised sea-weed which gives its name to the Sargasso Sea, and the minute plants which form the green, powdery deposits on old palings and walls. Yet these and an enormous number of intermediate forms of plants are grouped by botanists in the same sub-kingdom. It would be quite impossible, in a brief and simple account like the present, to enter into detail concerning the wonderful beauty and marvellous life histories of many of these forms. The majority of them are invisible to the naked eye, and since they are unknown except to botanists, they possess only technical names which would be meaningless to the general reader. They all possess chlorophyll, and can consequently build up food for themselves. Many of them form spores, which swim actively in the water; and some spores are capable of distinguishing between light and darkness, and of regulating their movements accordingly. And the lower

the forms which one studies, the more one is forced to the conclusion that protoplasm has essentially the same nature, whether it belongs to an animal or a plant. All protoplasm possesses the power of spontaneous movement, and the energy which enables it to move is derived from the oxidation, the "burning," of some of its substance; just as the movement of an engine depends upon the oxidation or burning of the coal or other fuel which drives it. Thus, all living protoplasm is constantly using up oxygen, and forming carbon dioxide and other simple compounds. We have seen that in daylight green plants possess in addition the power of taking carbon dioxide to pieces again, and fixing the carbon. To make up for the waste of substance which the life processes entail, fresh living matter must constantly be formed, and this cycle is incessantly going on, in the Oak tree, in the cow which chews the cud beneath its shade, and in the invisible organisms which turn the cow's milk sour.

But there is an immense number of plants which are not green, for they possess no chlorophyll, and are therefore incapable of manufacturing carbonaceous food for themselves. For this reason many such plants—called Fungi—are parasitic on other plants. There is before me a Rose tree which, although it is apparently in good health, is doomed. Some of its leaves seem to be drooping, and on turning them over one sees that they are covered below with an exceedingly fine, silky network. This network consists of the filaments of a Fungus, which is gradually draining the Rose of its life-blood. Nearly all the diseases of crops and of forest trees are due to certain Fungi. The moulds which destroy food are Fungi, and the dry-rot which ruins timber is caused by organisms of the same class. It would, however, be wrong to suppose that all Fungi are injurious. Many—Mushrooms, for example—are extremely good to eat, and others perform a most useful work in setting up decomposition, and thus removing waste matters which would otherwise accumulate and become a great nuisance. The smallest Fungi, the Bacteria, have been found of late years to be responsible for most, if not all, the infective diseases to which man is subject, and the investigation of the properties and life histories of these microscopic plants is consequently a matter of the most vital importance. It is already possible to control to a

great extent the action of the disease-producing germs, and, as it has been well said, "there is no reason, from the point of view of the biologist, why these lowest plants should not be cultivated and specialised as breeds and varieties for the service of mankind, as the Peach and the Strawberry, the Wheat and the Cabbage, have been."

Lastly, one finds creeping about in tanyards, and on dead leaves and rotting wood, naked pieces of protoplasm, often several inches in size. Whether these organisms are plants or animals is not definitely settled; they are probably on the borderland of the two kingdoms, and are chiefly interesting on account of the opportunity they afford of studying the activities of living protoplasm on a large scale.

V.—Evolution.

In the preceding sections, sketchy as they necessarily have been, enough has been said to indicate the vast diversity of structure among plants. The lowest plants consist of one cell only, and they reproduce their kind by the simple method of splitting up into two independent individuals, each of which resembles its parent. Closely related to these are the forms which consist of similar cells placed end to end. In such cases each cell has to do all its own work, but as we examine more complex types we find that different cells have different duties allotted them—a state of things which is obviously of great advantage to the colony. This division of labour becomes more and more marked as we ascend the scale of plant life, until in the highly complex flowering plants we find the principle carried out to a very perfect extent. Some of the cells, those containing chlorophyll, prepare the food, and thus act as the cooks of the community. To others is relegated the duty of distributing the nutriment to the various centres of activity. Other cells—which from their earliest days are most carefully tended and nourished—are told off to provide new individuals, and thus to continue the race. Yet others act as nurses for the young embryos, and feed them until they are sufficiently developed to provide for themselves.

It has been known for a long time that the gradually ascending scale of complexity which is thus observable among living plants is also to be found in fossil forms. The most recently formed

rocks contain specimens of plants which differ to no very marked extent from those alive at the present time; but as the botanist examines rocks of older date, he finds records of plants which depart very widely from the living species with which he is familiar. For example, much of the black rock we know as coal may be split into thin leaves, and when the pages of these leaves are carefully inspected they are seen to be covered with records of ancient life and climate. Stem, root, and spore-cases are there, with all their sharpness of outline unimpaired; the delicate tracery of frond and leaf is visible, as clear and fresh as if made yesterday. And such rocky herbaria tell us in unmistakable terms that our forest trees are parvenus, and that our humble Daisy is one of the greatest upstarts in existence.

It was from evidence of this kind that biologists were driven to the conclusion that the present forms of plant life represent merely a passing phase, to be succeeded in all probability by forms differing as widely from them as they themselves differ from the extinct species preserved in the rocks. It became clear that the earliest plants were probably exceedingly simple, and that they were succeeded by more complex forms, which gradually led up to those at present living. Notwithstanding this, it was generally supposed that each species was the result of a distinct creative act, and that the extinction which had clearly overtaken various races of plants in the past was due to catastrophes which had suddenly overwhelmed them. A few naturalists, however, came to the conclusion that the evidence of the rocks pointed to a process of gradual evolution, by which recent species had been derived from pre-existing ones *by direct descent;* but to what causes this process, if it existed, was due, they were unable to suggest. Matters were in this rather unsatisfactory state when, on October 1st, 1859, Darwin's book on *The Origin of Species* was published. In this epoch-making work, the author not only laid down the fundamental doctrine "that the innumerable species, genera, and families of organic beings with which the world is peopled have all descended, each within its own class or group, from common parents, and have all been modified in the course of descent," but he gave very sound reasons for supposing that such modification had been brought about.

These reasons may be grouped under four general heads :—

1.—It is perfectly obvious that of the innumerable fresh plants which are constantly brought into existence, only a small number can possibly reach maturity. The amount of plant-food on the earth is probably no greater than it was a million years ago, and it is extremely unlikely that there has been any marked increase in the total sum of plant-life since that period.

2.—The individuals which survive do so because they are in some respects better fitted than their contemporaries to cope with the difficulties and dangers by which they are constantly beset.

3.—There is a tendency for every fresh plant to resemble its parent or parents more than anything else.

4.—Just as no man is exactly like his father, so no plant resembles its parent or parents in every particular.

Let us now apply these considerations to our Wallflower. Wallflowers, like all other plants with gaily coloured corollas, have come into existence comparatively recently. They are descended from ancestors which had insignificant flowers. Now, suppose that, ages ago, one or two of the plants from which Wallflowers are descended happened to have blossoms which were slightly coloured. It is clear that in the struggle for existence these individuals would have a slight advantage over their more inconspicuous neighbours, for they would be more easily visible to such insects as frequented plants for the sake of pollen. Other things being equal, the chances of cross-fertilisation would be greater in the case of these fortunate plants than in that of their less favoured fellows. The new plants which resulted from such cross-fertilisation would not only be stronger and more vigorous on that very account, but they would also inherit from their parents a tendency to produce coloured blossoms. It would thus gradually come about that only such plants of the stock as produced coloured flowers would have any chance in the struggle for existence, which, as I have said, is extremely keen. The amount of colouration at this stage would, of course, be very small, but it would be quite sufficient to turn the scale. The process would still go on, and those flowers whose colouring was a little stronger than that of their competitors would again be favoured, until ultimately a distinctly new species would be produced.

The same method of reasoning may be applied to explain how Primroses and Cowslips probably came into existence as separate species. Let us admit that their many obvious points of resemblance indicate a fairly close blood-relationship, a descent along slightly different lines from a common ancestor. We may call this ancestor the Primula root-stock. As has been said, no plant resembles its parents in every detail; and it is easy to imagine that while one individual finds an advantage from a certain small variation, another is benefited by a slight departure from the normal of a different kind. Thus it was that from the Primula root-stock arose variations, increasing in intensity from generation to generation, which gave rise on the one hand to the length of flower-stalk characteristic of the Cowslip, and on the other culminated in the Primrose.

It becomes possible, reasoning on the lines indicated above, to explain to a very great extent the manner in which the various beautiful contrivances possessed by plants have originated. It is often noticed that cattle avoid certain grasses and other plants, which one would suppose, on casual inspection, to be in every way suitable for food. In many of these cases it is found that the leaves are closely beset by fine hairs, and the food becomes very unpleasant to chew. The reader may easily verify this for himself by mixing some of the grass known as "Yorkshire Fog" in his next salad. It is very probable that the ancestors of the "Yorkshire Fog" were by no means as hairy as their modern representative; but if some of the plants chanced to develop a few hairs, it is plain that they would be a little less likely to be devoured by browsing cattle, and would consequently have more chance of coming to maturity and setting their seeds. Their offspring would inherit a tendency to be hairy, and those in which this trait was most marked in their generation would be most likely to survive. Thus it would gradually come to pass that the smooth-leaved members would become extinct.

It is also by such a gradual development and fixation of favouring characters that weeds growing in agricultural crops generally contrive that the ripening of their seeds shall take place about the time the crop is gathered, in order that the seeds may be sown with the corn. And just as we owe the lovely colours and forms of flowers to the unconscious selection of insects, so

the most delicious flavours of fruits have been developed as baits for the allurement of such animals as are likely to scatter the seeds to the best advantage. It is noteworthy that edible fruits are generally of a colour which contrasts strongly with that of the surrounding foliage, so that they are easily seen.

The contrivances which plants have adopted to secure the due dispersal of their seeds are quite as ingenious in their way as the fertilisation devices I have already described. While wind-borne pollen is so loosely fixed that the slightest breeze is sufficient to carry it to other plants, it is generally the case that similarly transported seeds are so firmly attached that they are only broken away by gales strong enough to carry them a considerable distance. Other fruits are hooked, in order to catch the hairy hides of feeding animals, and are thus dispersed.

It is often found that an insect, which chiefly frequents flowers of a definite colour, has its own colouring arranged so as to match that of the flowers. This contrivance is also the result of natural selection, and it obviously screens the animal from observation.

It would be difficult to over-estimate the profound influence which Darwin's theory has had upon biological science. It has shown that the apparently chaotic assemblage of life-forms which exists upon the earth has arisen in obedience to a definite law of nature; and we owe to Darwin a conception of creation which is infinitely higher and more beautiful than any in vogue before his time. The study of the most insignificant weeds growing by the wayside, of the swarming life-forms which people every pond and ditch, raises in the mind of the biologist visions of a process, infinitely slow, "without haste, without rest," which has in the course of ages evolved from a formless speck of primeval protoplasm, not only the Oak tree and the Rose, but Man himself.

I have attempted in these five sections to show that plants, which we are too prone to regard from a merely utilitarian point of view, are worthy of the thoughtful and appreciative study of even the most unscientific.

The man who recognises, however dimly, that in every wayside blossom he has a friend with something interesting to tell, has pleasures utterly unknown to the learned pedants who

> "Love not the flower they pluck, and know it not,
> And all their botany is but Latin names."

Colouration of Flat Fishes.

WHOEVER has seen flat fishes alive, or even dead, but not divested of their skin, must have remarked the notable difference existing between the colour of the dorsal surface, exposed to the water, and the ventral surface which in the living state faces the bottom. While the dorsal surface is more or less covered, the ventral surface remains white. What is the meaning of this? The Weismann School—rather more Darwinian than Darwin himself—insists upon attributing the fact to natural selection. And this school, according to which the environment acts upon the living being, ascribes it to a physical influence —to the fact that the ventral surface naturally receives much less light than the dorsal. In truth, one can scarcely see what natural selection has to do with it. From the standpoint of the latter the colouration of the ventral surface seems indifferent, and, if it is not, it is permissible to think that it would be more advantageous to the fish to have this surface grey, like the dorsal, than white; that is to say, conspicuous.

Mr. Cunningham, of the Maritime Biological Association of Plymouth, has recently studied the phenomenon, and does not conceal his sympathy for the theory of the action of the environment. He experimented with young flounders *(Pleuronectus flexus)*, whose eye had not left the ventral surface. The pigment of the latter had already disappeared in great part. The animal was already lying on this side, and on the dorsal the pigmentation was pronounced. Mr. Cunningham made the following experiment:—

Darkening the cover and sides of a glass vessel, he placed the latter, containing some young flounders, upon a support, and beneath it arranged a mirror that reflected the solar light upon the bottom, so that the dorsal surface was exposed to darkness and the ventral to light; he reversed the normal conditions. The water was copiously renewed, and the fish had all the food that they needed. Other fishes were placed in a small vessel, which was normally lighted. The results were as follows:—Out of the thirteen fishes that received light from beneath, only three remained

like the one that received light normally. The others exhibited a varying quantity of pigmentary cells and chromatophores. Under these conditions, it really seems as if the absence of pigment in the animals in normal conditions is due to the difference of circumstances, and that light is the agent that determines the development of the pigmentary cells. It cannot be the only one, however, for pigments exist in many animals dwelling in the darkness of great depths.

Ants' Nests.*

BY DR. AUGUST FOREL. Plates XIX. and XX.

A NEST is a temporary or permanent, naturally or artificially formed hiding place, which serves as a dwelling for an animal and its family or for a more numerous society of animals. The nest is also intended, at the same time, for protection against enemies and against the inclemency of the weather and of the temperature. There are, however, not only purely natural nests (such as natural caves and hollows) and purely artificial nests (such as blackbirds' nests), but also, in many cases, mingled forms, where natural hiding places are completed by artificial help. Nests may also be divided into transient or season nests and permanent nests.

Now, in the case of animals which live in large societies—such as beavers, wasps, and ants—the nest becomes a complicated building or labyrinth. There are also elaborate and rough primitive nests.

The ants, or Formicidæ, form a great family of the insect order of the Hymenoptera. They number upwards of two thousand known species, which form about one hundred and fifty genera, distributed throughout the whole earth. All species of ants live in societies, and almost all display a peculiar so-called polymorphism ; that is, every species consists, not only of a female, usually

*Translation of *Die Nester der Ameisen.* Von Dr. August Forel, Professor in Zurich. *Neujahrsblatt der Naturforschenden Gesellschaft zu Zurich*, 1893. From *Smithsonian Report*, 1894.

winged, and a male, usually winged, differing extremely from each other in the whole structure of their bodies, but also of other individuals without wings, which are offspring of the female sex, and are called "workers." The division, however, goes still further in certain species, the "worker" caste being subdivided into two kinds, differing greatly in their physical structure— "workers" and "soldiers." Between these there are species with intermittent workers, the largest of which resemble the "soldiers"; that is, form a phylogenetic precursor to the "soldiers."

Most of the female and male ants are winged, and copulate in the air or in the tops of trees; but at least one of the sexes is always winged. The new colonies are almost invariably founded by a pregnant female, or by several such, as has already been stated by Huber, and has been clearly proved in recent years by Mc.Cook, Lubbock, Blochmann, and others. These females live many years (eight to twelve years, according to Lubbock's experiments), and always remain prolific without renewed copulation. They are the mothers of the whole so-called ant colony, which, consequently, lasts many years, and does not die out annually like the wasp colony. It follows from the facts stated that the ants must have permanent nests, and that these nests must display great variety, both of which inferences are correct.

The ants have, moreover, the peculiarity of changing their abode from time to time in order to move to a new one. They understand how to change their dwelling and how to build new ones.

Many species of ants understand likewise how to colonise; that is, how to build new nests at a certain distance from their dwellings without leaving their old nest. It is in this way that mighty colonies, with numerous nests, are founded, resembling, to use Huber's words, the cities of one and the same empire. I have counted as many as two hundred immense nests standing close together in our European *Formica exsecta*, Nyl., and Mc.Cook has counted as many as sixteen hundred still larger nests of one and the same colony of *Formica exsectoides*, Forel, in the Alleghanies of North America. These latter ant kingdoms have, in all probability, a population of 200,000,000 to 400,000,000 inhabitants, all forming a single community, and living together in active and

friendly intercourse, while they are on hostile terms with all other colonies of ants, even those of the same species. Certain kinds of ants which live in trees form similar kingdoms by occupying numerous trees of the same forest.

In addition to this, ants frequently construct annexes to their nests—covered ways, subterranean passages, stations, and flying camps—in order to protect the plant lice which serve them as milk cows, and also for other purposes.

It is further to be remarked that there are courageous, warlike kinds of ants, whose nests are, consequently, open and easily discovered, while other kinds are timid and live in concealment, in many cases, because their colonies consist of only a few individuals. There are, besides, ants with good eyes, which make their nests above ground, and even on the boughs of trees, while there are blind and half blind kinds which live hidden deep underground.

As I have formerly asserted (*Fourmis de la Suisse*, 1874), the chief feature of ant architecture, in contradistinction to that of the bees and the wasps, is its irregularity and want of uniformity—that is to say, its adaptability, or the capacity of making all the surroundings and incidents subserve the purpose of attaining the greatest possible economy of space and time and the greatest possible comfort. For instance, the same species will live in the Alps under stones which absorb the rays of the sun ; in a forest it will live in warm, decayed trunks of trees ; in a rich meadow it will live in high, conical mounds of earth.

I will attempt to make a classification of the nests of ants, corresponding approximately to that which I formerly made with a view simply to giving an outline of the variety of the dwellings of ants. Of course, taking into consideration the above-mentioned features of ant architecture, it is impossible to be systematic.

1.—Taking Advantage of Existing Cavities.

Many ants use as nests simply the clefts and crevices of rocks and the space between two stones. They wall up and barricade the exterior of the clefts with sand, pebbles, and dry vegetable particles ; they divide the surface, more or less, into chambers, and

leave only one or a few doors (holes) open, to allow themselves egress. Many species of the genus *Leptothorax* live in this way, in small colonies, and *Plagiolepis pygmæa*, Latr., *Cremastogaster sordidula*, Nyl., *Prenolepis longicornis*, Latr., etc., in larger colonies, in the same manner.

Some such species have adapted themselves specially to mankind and occupy the walls of our houses. They know how to avail themselves there of the space between the stones; they bite away the mortar with all their might and carry it away in order to procure for themselves safe and warm lodgings in the neighbourhood of our domestic stores, which they pillage thoroughly at the first opportunity. Such ants which have adapted themselves to the walls of our dwellings are *Lasius emarginatus*, Latr., *Monomorium pharaonis*, L. (imported into seaports from the Tropics), *Pheidole megacephala*, Fabr. These insects, as is well known, become house nuisances.

But other natural cavities are also made use of, especially those made by other insects. The species of *Leptothorax* and *Colobopsis* with us, those of *Polyrhachis* and *Cremastogaster* in tropical countries, know how to make use of the cavities of galls which have been abandoned by the gall-fly for their nests.

Fig. 1, Pl. XIX., represents a stem-gall from Delagoa Bay, South-east Africa, one-sixth smaller than the natural size, which was inhabited by a colony of *Polyrhachis gerstäckeri*, Forel, and which was sent to me by our countryman, the missionary physician, Dr. Liengme, living there. The *Polyrhachis* had affixed some of their weaving to the inside, *B*. The egress opening made by the gall-fly was the door of their nest. Cavities made by bark beetles in wood are used among us as nests by the species of *Liometopum* and *Lasius*, and especially by *Lasius brunneus*, Latr., *Formica fusca*, etc. In the same way the space between the outer layers of the bark of trees (especially the conifers), the under side of the bark of dead trees, the under side of beds of moss, etc., are used as nests by the species of *Leptothorax* and other small ants. Ants also live frequently in hollow fruits, potatoes, and, above all, in large tropical fruits. Mr. Ortgies found the little *Brachymyrmex heeri*, For., in the lower part of the pots of the tropical orchids in the Zurich hot-house, which were filled with

moss, etc. My friend and colleague, Professor Stoll, found the nests of *Camponotus atriceps*, Sm., race *stercorarius* (Forel), constantly under the dried excrement of cattle, and even inside of it, in Guatemala.

Père Camboué, in Antananarivo, Madagascar, sent me a stalk of *Solanum auriculatum*, the soft marrow of which, excavated and divided into compartments, served as a nest for *Technomyrmex albipes*, Smith. In this case the gnawing capacity of the ants had made the natural object serviceable. A portion of this nest is represented in Fig. 2, two-thirds of natural size.

Dr. Göldi, in Rio Janeiro, sent me several specimens of *Camponotus cingulatus*, Mayr., a very handsome, rather large ant, as the regular inhabitant of the hollows (internodes) of the bamboos there. Père Camboué, in Antananarivo, sent me *Prenolepis ellisii*, Forel, from the hollow stalks of one of the Malvaceæ, in which it lives. Major Yerbury, of Ceylon, sent me, by Mr. Wroughton, *Camponotus reticulatus*, Roger, with its nest, which was also in a hollow stalk. Mr. Wroughton, divisional forest officer at Poonah, India, sent me the nests of a very small ant, *Cardiocondyla wroughtonii*, Forel, which he had found in the space between the two surfaces of the leaves of a tree (*Eugenia jambolana*), the parenchym of which (the green of the leaf between the exterior membranes) had evidently been devoured by a very small caterpillar. This nest of *Cardiocondyla wroughtonii* is represented in Fig. 3 by Mr. L. Schröter.

The well-known ant nests in the hollow acacia thorns of tropical lands also belong to this class; but more on this subject hereafter.

2.—Earth Nests.

Earth is the most usual material for the nest-building of ants. It is well known (Gould, Huber, etc.) that the ordinary earth structures (mounds) of many of our ants are created by the workers mining under ground after rainy weather, bringing the wet particles of earth to the surface of the ground, and pressing them into walls and vaults by means of their mandibles and forelegs, using at the same time blades of grass, etc., as pillars and inside walls. In this way are made the well-known labyrinths, which I

myself have watched innumerable times. It is, however, an unsolved problem whether really, as Huber thought, water alone always suffices as cement for the earth or whether it is not in some cases mixed with a secretion of the glands of the ants. The great firmness of certain structures—for instance, those of *Lasius flavus*—gives some probability to the latter supposition, particularly when we consider the fragile character of the structures of other kinds of ants.

Earth nests may be divided into three classes :—

(a) Nests which are entirely excavated.—In this case passages and chambers are simply excavated in the ground, without the particles of earth which are dug out being worked up into an artificial upper structure ; they are merely thrown away. There are many kinds of ants which mine only in this way, as, for example, *Ponera contracta*, Ltr., *Myrmecocystus*, all the *Dorylides*, *Aphænogaster subterranea*, Ltr., and, in general, most of the blind and half-blind species. Besides these, many other species do it occasionally, such as *Formica fusca*, L., *Formica rufibarbis*, F., *Tetramorium cæspitum*, L., species of *Myrmica*, etc.

One variety of the mined nests consists of those in which the ants heap up the excavated earth in banks around the openings of the nest, so that crater-shaped openings are the result. This occurs most frequently in sandy soil. These banks are not genuine upper structures, although they often resemble them closely. We find them in the case of *Messor structor*, *Messor barbarus*, species of *Pheidole*, *Acantholepis frauenfeldi*, *Pogonomyrmex*, etc. A peculiar variety of this class is formed by the crescent-shaped mounds of *Messor arenarius*, Fab., first noticed by me in the South Tunis desert near Cabes, which consist of coarse but very perishable globes of sand. At certain times the apertures of the *Messor* nests are, in addition, surrounded by mounds composed of the hulls of the seeds which have been gathered, which hulls have been thrown out of the nests. The little *Cardiocondyla elegans*, Em., and *stambuloffii*, Forel, make small nests in the sand on the seashore.

The subterranean structures of some kinds of ants are, in certain cases, extremely interesting. Certain species dig passages which go down very deep and branch off laterally, forming subter-

ranean corridors, and in many cases leading to root plant lice *(Lasius flavus)* or serving for other purposes. The underground hunts of the species of *Dorylus*, or visiting ants, are partially carried on in this manner. These are blind robber ants, which carry on an underground hunt after all conceivable ground insects, as I myself have observed in Tunis. They are also called "visiting ants," because they frequently make a sudden attack at night upon dwelling-houses and destroy all the vermin in them.

The species of *Messor* (Europe), *Pogonomyrmex* (America), and *Holcomyrmex* (India) construct under ground, at a considerable depth (often at the depth of a yard), very large chambers or granaries, in which they store the seeds which they have gathered. In the same way the species of the American genus *Atta* excavate extremely deep and extensive passages and make immense chambers, in which they store the leaves which they have cut from trees, in order to lay off upon them the fungus gardens from which they supply themselves with food. This discovery, which was first made by Belt and subsequently declared by McCook to be incorrect, has been recently confirmed by Dr. Möller, of Blumenau, in its full extent and by superb experiments.

A great deal of interest is likewise attached to the underground hunts carried on by the ants of the genus *Lobopelta* in India, after the termites, according to the careful observations of Mr. Wroughton. They feed upon these white ants, and pursue them in their own passages. I conjecture that the same thing is true of the various species of the genus *Leptogenys*, and that they use their long, thin, pointed, sickle-shaped jaws, which bear a strong resemblance to a curved needle, to pierce the termites, which they then devour by the aid of their comparatively powerful under jaw.

(*b*) *Nests under stones.*—As is well known, wherever there are stones on dry declivities, etc., innumerable ants' nests are found under them. The stone serves as a roof, under which are the most beautiful corridors and chambers. Under these lies the mined nest. The stone serves, above all, to produce a speedy warming by means of the rays of the sun. The ants under it are always in the highest story, in damp or cool weather, as soon as the sun shines or begins to penetrate. As soon as the sun dis-

appears the insects go below. They also go below when the sun shines too strong.

The same species which mine, and which build earthen structures above ground, also live under stones as soon as they find any. The stone must be neither too small and thin nor too thick and large. Stones of 2 to 15 centimetres in thickness are the most desirable, according to the size of the ants and the extent of their colonies. They allow the best regulation of the heat for the brood.

The species of *Lasius*, *Formica*, *Myrmica*, *Tetramorium*, *Plagiolepis*, *Pheidole*, *Camponotus*, *Aphænogaster*, *Bothriomyrmex*, *Tapinoma*, and other genera, are found in swarms under stones among us in Europe. There are few genera of ants that never live under stones.

(c) Earth structures above ground.—Many kinds of ants are excellent masons, but by no means all. It is easier to mine than to construct walls, vaults, and pillars.

I advise everyone who wishes to see one of the most beautiful displays of animal instinct and animal intelligence to equip himself with an umbrella, and with patience, on some warm day in May, when it begins to rain after a drought, or when it has just stopped raining, to repair to a meadow, and there, with the greatest perseverance, to watch attentively the surface of the ant-hills and the actions of their occupants. He must at the same time watch closely individual ants and their work. He will then admire the skill and foresight of these insects, and will see how the little architects and masons understand how to turn every blade of grass, every stalk, every leaf, to account by means of their earth mortar, in the erection of vaults, pillars, walls, etc. In this manner are made those no less numerous than wonderful earth labyrinths which serve the ants in our meadows as conical superstructures. Our Fig. 9 represents a fragment of the mound of an earth nest of *Lasius niger*. It can be seen how blades of grass and leaves are used in the masonry as pillars, arches, etc. The drawing, which is two-thirds of the natural size, was made by Mr. L. Schröter, like all the others, from the original piece, which I had hardened with a solution of silica. I need not add that a mined

nest always lies under the superstructure of the mound-building ants.

What purpose does the latter serve? Judging from my own observations, the same purpose as the stones—to wit, to procure warmth for the brood. The grass springs up in May, and with it the ant mounds. These afford protection against the dampness and the shade of the primeval forest; for such is a meadow to the ants. Up there, under the roof of the mound, the rays of the sun are felt. We have in Europe a small ant (*Tapinoma erraticum* Latr.), whose perishable earth structures, first described by me, can, to all appearance, serve no other purpose. It builds hastily around the blades of grass a comparatively very high and steep mound of earth, which consists of little more than the upper, superficial, thin vault. Inside there are often only a few wretched thin chambers, especially where the grass is thick. The ants hold their brood partly in their upper jaws, partly lay them on leaves. They crowd together under the mound to warm themselves in the rays of the sun. After the harvest the mounds of the *Tapinoma* disappear, while those of the other ants remain standing. The latter, however, also become more and more flattened as autumn approaches. Our Fig. 12 represents the perpendicular cross section of a nest of *Tapinoma erraticum*, Latr., from Vaux, Canton Vaud, Switzerland, which was strengthened and preserved by me by means of a solution of silica, and is now in the Entomological Museum of the Federal Polytechnikum. Mr. L. Schröter has drawn the nest two-thirds of the natural size. *D*, the temporary earthen cupola; *Mn*, the beginning of the underground mined structure.

Among us mounds of earth with labyrinths are built by all the species of *Lasius*, with the exception of *Lasius fuliginosus*, Ltr., *brunneus*, Ltr., and *emarginatus*, Ol.; also by *Tetramorium cæspitum*, the species of *Myrmica*, several of *Formica* and *Camponotus*, and the species of *Tapinoma*; and in Tunis by *Monomorium salomonis*, *Aphænogaster striola*, *sardoa*, *testaceopilosa*, *crocea*, etc. The best artist is the most common of all ants, *Lasius niger*, L., which swarms in all our gardens. This ant also constructs covered passages along the stalks of plants, where in this way it walls up its plant lice and cochineal kermes in artistic stalls. The species

of *Myrmica* frequently build earthen stalls around the plant lice on the stalks of plants without putting them in communication with the ant-hill by a covered way.

In the island of St. Thomas I saw earthen structures made by *Solenopsis geminata*, F. In Australia the large species of the genus *Myrmica*, which are 20 to 28 millimetres long, build immense nests of earth.

A seed-harvesting ant in Colorado, *Pogonomyrmex occidentalis*, Cresson, builds a very peculiar and isolated variety of the earthen mounds. It plasters or paves the whole upper surface of its earthen mound uniformly and in mosaic with a layer of small white stones, which, according to McCook's observations, it frequently brings from a great depth in the ground. The still unknown object of this paving is probably the same as that of the earthen mounds in general. It is extraordinary that the little paving stones are placed side by side with great regularity like a street pavement, while the interior of the cupola contains no stones whatever. McCook has even seen upon these mounds stones containing fossil remains and native gold. Mr. Henry de Saussure, of Geneva, made similar observations before McCook among the genuine *Pogonomyrmex barbatus*, i. sp., Smith, but did not publish them.

3.—Wood Nests.

There are also woodcutters among the ants, and in not a few cases the same species knows how to make earthen structures and how to hollow out wood, as, for instance, our *Camponotus ligniperdus*, Latr.

The best woodcutters are those species of the genus *Camponotus*, Mayr, which have a short, broad head, rounded off in front, especially the sub-genus *Colobopsis*, Mayr.

These ants frequently bore with their short, powerful jaws into the very hardest wood, and construct secure and elegant labyrinths for themselves in it. This is the case with *Camponotus pubescens* in Wallis and Tessin, and *Camponotus marginatus*. The latter bores into the softer layers of the wood when they are somewhat decayed and lets the harder part remain, so that its nests are more concentric around the centre of the bough or trunk in their

arrangement. I have noticed them in cherry trees and Paulownias.

The smaller and very timid species of *Colobopsis* build themselves nests in the hardest wood. These nests open outward by only a very few small apertures, which are concealed by the irregularities of the bark of the tree. These apertures are kept closed by the head of a "soldier" sentinel, who permits only friends to enter. The soldier's head is broadened and rounded off in front, evidently for this very use. The rounded surface (front view in Fig. 11, magnified ten times) is rough, of a dull-brown colour; the feelers are planted back of the rounded surface, so that the latter presents no hold and blocks up the entrance to the nest like a living stopper. I first observed this fact among our *Colobopsis truncata*, Spin, at Vaux, Canton Vaud (Fig. 13, drawn four-thirds of the natural size) but the similar structure of the head and the habit of living in trees, which characterise the other species of *Colobopsis*, lead us to infer that they live in the same way.

Fig. 13 represents a portion of the original piece of a nest of *Colobopsis truncata*, discovered by me in a very hard, dead bough of a pear tree. *B* is the bark of the pear tree; *Ch* is the chambers and passages of the nest; *O* is the exterior opening of the nest; behind it, in the gallery of egress of the nest, stands a *Colobopsis* "soldier" as a sentinel, keeping the door closed with his head. At *W* are seen two *Colobopsis* workers, one hastening toward the door from the outside, the other standing in the nest. The soldier will go back into the nest for a moment in order to let the first worker come in (I have noticed this among the living ants). That the part played by the *Colobopsis* "soldier" is that of a living stopper is further proved by the fact that there are comparatively few of them, and that in contrast to the workers they hardly ever go out. Fig. 19 represents a "soldier," still more magnified, standing at the door of egress.

Those species of *Camponotus* which live in a similar way—such as *Camponotus marginatus*, Latr.—display the beginning of a similar rounded surface on the front part of the head, and always have a large-headed sentry at the door.

Leptothorax acervorum, F., cuts small, very simple nests, spread out flat, with few chambers in the outer layer (the cork layer) of the bark of the tree. Fig. 5 represents such a nest two-thirds of the natural size in the bark of a fir.

4.—Combined Structures.

The structures heretofore described are combined in a variety of ways.

For instance, the hollow stalk of a large Arcangelica is filled from top to bottom with small earthen chambers by *Lasius niger* and occupied by them. Decayed trunks of trees are made use of by ants which elsewhere build in the ground, excavated, and worked up into nests by *Lasius niger*, *Lasius flavus*, *Formica fusca*, *Myrmica lævinodis*, etc. Here wood dust and earth are used as mortar in the construction of chambers and galleries. *Formica rufa*, L., excavates the softer portions of the wood in half-decayed trunks of trees, and build in them labyrinths which form a part of its nests.

Lasius brunneus, Latr., lives habitually in half-rotten trunks of trees and beams, after excavating the moist, decayed wood. It also lives in decayed woodwork in our houses, as do likewise frequently *Lasius umbratus*, Ngl.

The architecture of the group of forest ants—*Formica rufa*, L., *pratensis*, De Geer, *truncicola*, Nyl., *exsecta*, Ngl., and *pressilabris*, Nyl., as well as of their North American relatives, *F. exsectoides*, Forel, *integra*, Nyl., *obscuripes*, Forel, etc.—is, however, more imposing and more interesting.

These ants mine the ground, but cover their nests with dry vegetable matter of the most varied kinds—pine and fir cones, dry leaves and pieces of wood, snail shells, little balls of rosin, blades of grass; in a word, with every kind of round and cylindrical materials. With these they build the well-known immense mounds, with their singular framework and the indescribable interior labyrinth, the most thoroughly perforated part of which is in the middle, at about the level of the ground. Earth serves partially as cement. The openings of the nest are carefully closed with small pieces of wood at night or when it is raining. They are opened by the workers in the morning and generally in warm, fine weather.

The mound is gradually enlarged and strengthened by materials dragged to it. It protects the interior perfectly against cold and rain.

Formica rufa, i. sp., of the fir woods, uses chiefly fir leaves *Formica pratensis* of the meadows builds flatter mounds and uses more pieces of wood and blades of grass, pieces of dry branches, etc.; *Formica exsecta* uses more particles of dry leaves, etc.; *Formica sanguinea*, Latr., builds mounds composed of the above-mentioned materials and earth; its work is partly that of a carpenter and partly masonry; the latter, however, which is executed by the "slaves" *(Formica fusca)*, usually prevails.

It is impossible for us to describe everything, and we refer our readers to Huber's admirable description of the way in which the forest ants and the earthen-mound ants build their nests. It may well be said that almost every species—either in earthen structures, in wood nests, or in combined structures—has its peculiarities with regard to the quality of the material, the fineness of the grain, the shape and arrangement of the mound and the labyrinth, the comparative thickness of the walls, the size of the chambers, etc., so that the species may frequently be known by the structure.

Still the ants often rob one another's nests, and this frequently renders it difficult to recognise the architect.

There are species, it is true, whose architecture can hardly be distinguished, as, for instance, the little species of *Myrmica*.

5.—Pasteboard Nests and Spun Nests.

I have already, in the *Mittheilungen of the Swiss Entomological Society*, Vol. VIII., part 6, 1891, given some information with regard to the singular nests which are now to occupy our attention. A well-known European species, *Lasius fuliginosus*, Latr., builds peculiar pasteboard nests, which Huber erroneously thought to be excavated in wood, while Meinert, Mayr, and others, including myself, have demonstrated their true nature beyond a doubt. They are composed of the finest particles of wood dust or of earth and small stones, which, by means of a viscous substance secreted by the ants, are worked up into so strong a pasteboard (see Forel, *Fourmis de la Suisse*, pp. 181—187) that the partitions between the excavations are extremely thin (as thin as visiting cards). These nests are mostly found in hollow trees. That they are not excavated, but are composed of pasteboard, I have clearly shown by microscopic cuts. Meinert first called attention to the fact that

in *Lasius fuliginosus* the glands of the upper jaw are extraordinarily large, and conjectured that they are the glands which secrete this viscous substance (cement). In fact, a comparative physiological study of this gland which Wolff ("The smelling organ of bees") erroneously designated as the smelling-mucous gland, shows that a discovery which has been misinterpreted by Wolff is of special value.

The substance secreted by this gland, both in bees and in ants, and also the secretion of the posterior glands of certain ants (the *Dolichoderides*, with whom it serves as a weapon for smearing the faces of their enemies), is immediately decomposed at the first contact with the air, with a violent production of gas-bubbles and the development of an aromatic odour which is very peculiar. As soon as this chemical decomposition is completed, the residue of the secretion is transformed into a resinous, viscous mass, which is very sticky. There is no doubt in my mind that the viscous substance formed in this way is not a smelling mucus, as Wolff, by a very far-fetched explanation, which is untenable for many other reasons, would have it, but forms the cement with which the nests and many other things are welded together.

What is still too little known, however, is the manner in which a genuine phylogenetic evolution converts this gland cement gradually into spun threads. The pasteboard of *Lasius fuliginosus*, Latr., is very rich in wood dust or earthy matter and very poor in cement, so that it is very brittle. There is a drawing of it in my *Fourmis de la Suisse*, Pl. II., Figs. 32 and 33. The pasteboard which *Liometopum microcephalum*, Pz., manufactures in the innermost hollow of venerable but, nevertheless, strong, handsome, hard, large trees, and which is also composed of wood dust, is somewhat less brittle. They make it in oaks, poplars, apricot trees, etc., in south-eastern Europe. Mayr gives a drawing of it, taken from a photograph, in the *Proceedings of the Imperial Royal Zoological and Botanical Society of Vienna*, June 1, 1892, Vol. XLII., Pl. V., Fig. 7. A great many species of the genera *Cremastogaster*, Lund, and *Dolichoderus*, Lund, build only pasteboard nests on the boughs of trees, and these nests vary very much in their nature. In some cases the pasteboard is harder and more brittle, resembling wood, as among the species just described; in

other cases it is thinner and more elastic or flexible, but at the same time has much greater power of resistance, and is much more like paper or pasteboard, like that of wasps. *Cremastogaster stollii*, Forel, of Guatemala, builds very peculiar galleries of pasteboard along the trunks of trees between the projecting portions of the bark. They were discovered in these galleries by my friend, Professor Stoll, who communicated this circumstance to me. In *Cremastogaster ranavalonæ*, Forel, of Madagascar, the pasteboard of the inside of the large, round, tree nest is thicker and more brittle; that of the outer portion is always thinner, more elastic, and finally, in the outermost layers, even perforated, having a reticulate appearance, somewhat like loosely woven packing cloth. The nest of *Cremastogaster ranavalonæ* is represented in my *Formicides de Madagascar* (from Grandidier's *Natural History of Madagascar*, Vol. XX., Part 28, Pl. VI., Fig. 4, 4*a*, and 4*b*, and Pl. VII.). The nest of *Dolichoridus bispinosus*, Oliv., which is composed of the seed hairs of a tree of tropical America (the wool tree, *Bombax ceiba*, L.), woven together with gland cement, is very similar in appearance to the outer portions of this nest, but still more coarsely perforated and more netlike. Fig. 18 represents a small piece of this substance microscopically magnified. *Fib.* represents the vegetable filaments, which are only moderately dismembered, so that their structure may easily be seen; *Cem.* is the ant cement, the colour of which varies from yellowish to brownish, and which can be recognised by its shapelessness and its colour; *Mesh.* represents the empty meshes of the network. Thanks to the coarseness of the substance, which is, consequently, in an almost unscathed and unpulverised state, the ant cement can be better distinguished from vegetable building matter in this case than in the other kinds of ant pasteboard.

Fig. 15 represents, in one-third the natural size, the photographed nest of *Dolichoderus bituberculatus*, Mayr, of Bangkok, which was sent to me by the late lamented and well-known turner, Mr. Heinrich Sigg, of Zurich. This nest is composed of a compact (not perforated) but fine-grained pasteboard, greatly resembling that of the nests of the common wasp (*Vesta germanica*), but stronger. A section of the nest was taken off perpendicularly in order to show the structure of the interior. The nest is resting

in its natural position on the bough where the ants had placed it. It can be seen how the small branches and leaves of the tree, glued together with pasteboard, are incorporated into the nest, and how the main bough serves as an axle to support the structure. It can be further seen how the labyrinth, constructed of pasteboard, is built more or less concentrically around the bough.

Some species of the genera *Camponotus* (*C. chartifex*, Smith, *traili*, Mayr, *fabricii*, Roger, etc,), in South America, and *Polyrhachis*, in the East Indies, manufacture a very similar pasteboard. Fig. 4 represents a nest of *Polyrhachis mayri*, Roger, of Ceylon. The whole nest of most of the species of *Polyrhachis* consists of a single cavity of the size of a walnut or of a hen's egg, while the nests of other ants are, for the greater part, divided into chambers and passages. The egg-shaped nest of *Polyrhachis mayri*, which I received from Major Yerbury, of Ceylon, through Mr. Wroughton, stands simply, like the cocoon of the silk-worm, on a leaf. The pasteboard of which it is composed resembles that of a *Cremastogaster* nest, but is very weak and fragile, being made of vegetable particles slightly glued together with gland cement. A silk thread has never yet been discovered in any of them. The cement is in the form of yellow or brownish flakes and crosspieces, precisely like that of *Dolichoderus bispinosus* (Fig. 18, the coloured parts), while the vegetable matter is entirely compact (without meshes) and more finely dismembered, though still recognisable in its structure (not pulverised); the walls of the nest are about half a millimetre thick.

Polyrhachis scissa, Roger, of Ceylon, builds its nest of exactly the same materials; but it is irregularly formed, and is attached to leaves rolled around galls, the crevices of which are closed with paste.

I have received similar pasteboard nests of *Dolichoderus gracilipes*, Mayr, and of a species of *Cremastogaster* fixed upon leaves, from Ceylon, through Major Yerbury.

The nest of the *Polyrhachis jerdonii*,* Forel, which I received

* *Polyrhachis jerdonii* (workers), n. sp. $4\frac{1}{2}$ millimetres in length, short and broad; related to the *Polyrhachis argentea*, Mayr, but still shorter, without silvery down, with a much less arched thorax sharply edged at the side, the abdomen sharply edged in front, with red mandibles, antennæ, and legs (except

from Ceylon through Major Yerbury, is very interesting. This species builds upon leaves small nests, the wall of which greatly resembles in appearance the shell of many *Phryganeidæ* larvæ. Pebbles, and especially small fragments of plants, are cemented together by a fine web or woven together, and form a rather soft and tough web-like nest wall of a bright greyish-brown colour. Fig. 17 gives a microscopic picture of this nest wall. We see here unmistakable small fragments of plants (Schol.), bound together in a web by peculiar silk threads (Gesp). These silk threads are found, upon a closer examination, to be of very irregular thickness, often branching, and in many cases issuing from a thicker crosspiece. Upon calling in the aid of the still more magnified web of *Polyrhachis dives*, Sm. (also from the East Indies), in Fig. 7, there can be no doubt that a viscous substance secreted by the glands, similar to that which we have seen used as glue by the ants previously described, is here simply drawn out into threads. In Fig. 7 are seen the thicker crosspieces of a still more shapeless mass of cement and the more finely spun threads drawn transversely out of them.

Polyrhachis dives, however, no longer needs any foreign material. It makes its nest wall out of pure silk web, exactly like coarse spun yarn or the web of the caterpillar. The web is of a brownish yellow, and is fixed between leaves, which are lined with it and bound together. Mr. Wroughton, of Poonah, India, sent me such a nest, simply between two leaves.

A still finer, softer silk web, finer and thicker than the finest silk paper, very soft and as pliable as the finest gauze, though much thicker, of a brown colour, is produced by *Polyrhachis spinigera*, Mayr. Fig. 16 presents a microscopic picture of it. Here we

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the tarsi). The other parts are of a dull black, thickly and regularly punctate-reticulate, and with very fine, yellow, sparse, recumbent, and almost no erect hair. The head is wider than long, and broadens out very much behind. The clypeus is short, without flaps in front, not carinate; the laminæ diverge behind. The scape of the short frontal antennæ is somewhat in the shape of an S, and hardly extends beyond the back of the head. Scales between the spines, with a convex, emarginated upper border. Spines just like those of *Polyrhachis argentea*. The sculpture of the head is like the meshes of a net, with a dotted background. The body is dotted like a thimble.

find no more crosspieces, but only silk threads. They are, however, still irregular, of varying thickness, spun across each other into a web. This web is fixed in a wonderful manner in the ground, where it forms the lining of a funnel-shaped cave, which is widened out into a chamber at the bottom. The honour of the discovery of this highly interesting nest is due to Mr. Wroughton; he found it in Poonah, India. Mr. L. Schöter made the somewhat schematic drawing of the nest, in its natural position, from an original sketch by Mr. Wroughton (Fig. 8). We refer the reader to the drawing and to the explanation of the plates.

The large nest constructed in the foliage of trees, between the leaves, by *Œcophylla smaragdina*, Fabr., one of the most common ants of tropical Asia and tropical Africa, forms, however, the prototype of spun ants' nests. A great number of leaves are fastened together by a fine, white web, like the finest silk stuff. This web, apart from the colour, has exactly the same appearance, both to the naked eye and under the microscope, as that of *Polyrhachis spinigera*. The leaves are usually fastened together by the edges. The nest is large, and the large, long, very vicious, reddish to greenish worker ants live in it, with their grass-green females, their black males, and their whole brood. They form very populous colonies in the branches of the trees. Fig. 10 represents a portion of the nest of *Œcophylla smaragdina*, with the web and the borders of the leaves which are fastened together.

Now, how do the ants spin? This has, unfortunately, so far as I know, never yet been observed sufficiently closely. Not even the way in which the pasteboard of our European ants is made has been discovered. *Lasius fuliginosus* has never consented to work before my eyes. At all events, the spinning of *Œcophylla*, which works in broad daylight, ought to be the first to be seen, and, in fact, the only minute observations on this subject known to me, by E. H. Aitken, in the *Journal of the Bombay Natural History Society*, 1890, Vol. 5, No. 4, p. 422 ("Red Ants' Nests"), now lie before me.

Aitken saw how *Œcophylla* fastened two leaves together. A worker went to the base of the two leaves, at the point at which they began to separate, placed his hind legs, which are furnished with sharp claws, upon one of the leaves and drew the other leaf

towards him with all his might with his upper jaw. If the distance was too great, from two to five ants chained themselves together for this task, each grasping the body of one of the others, the first holding one leaf with his mandibles, the last seizing the other leaf with the claws of the tarsi. While the edges of the two leaves were held as close together as possible, simply by these chains of ants working side by side, with the application of all their strength in the utmost tension, as if by india-rubber bands, Aitken saw other ants zealously engaged in binding the edges of the two leaves together with strong silk threads or ropes, which they spun closer and closer together the nearer the leaves approached each other. When a sufficient number of leaves had been fastened together in this way by their edges, the whole was rendered waterproof by a compact silk web, and was divided into chambers and passages by a similar web. Aitken is a reliable and accurate observer. This highly interesting observation of his is entitled to full credit. Only one thing is wanting to it, to wit, the information from what part of the body of the ant the silk thread issues. This must likewise be observed.

In my opinion, however, there is no doubt that the silk thread of *Œcophylla* and of the spinning species of *Polyrhachis*, like the cement of the other species of *Polyrhachis*, many of *Cremastogaster* and *Dolichoderus*, *Lasius fuliginosus*, etc., is formed from the so-called mouth saliva, and most probably from the secretion of the glands of the upper jaw. The cells of these glands, at least in *Œcophylla*, are large and numerous.

6.—Symbiosis and Kindred Relations between Ants and Plants.

By symbiosis, in the more restricted sense, is meant the mutual services of two organisms living together, which, by a defensive alliance in the struggle for existence, are so dependent upon each other that the one cannot thrive well without the other. The formation of special morphological characteristics is usually combined with genuine symbiosis. There are, besides, all possible forms of imperfect symbiosis, displaying transitions to parasitism, etc.; above all, however, those in which only one of the

two organisms is really dependent upon the other. For example, the small beetles *Lomechusa* and *Atemeles* cannot live without their ant-host. On the other hand, the ant can exist very well without such guests, and merely eats the secretion from the hair clusters of the beetles as a dainty (see Wasmann's elegant *Observations on the Biology of the Guests of the Ants*). There are, however, cases of still more imperfect, counterfeit symbiosis, where one organism entirely ignores the other, and, lastly, casual relations which are erroneously regarded as symbiotic.

The relations of certain ants to certain plants give rise to very peculiar forms of nests, of which we will speak briefly.

(a) Genuine symbiosis.—Dr. Fritz Müller, of Blumenau, South Brazil, has discovered the real relation of the *Cecropia* trees (the imbauba of the Brazilians) to *Azteca instabilis*, Smith. The ant genus, *Azteca*, Forel, which is related to *Liometopum*, Mayr, contains several American species, but the biology of *Azteca instabilis* only is known. Prof. A. F. W. Schimper (*The Varying Relations between Plants and Ants*, Jena, 1888) has given us in his excellent work his own observations in South Brazil, which substantially complete those of Müller.

Azteca instabilis lives only in the hollow trunks of certain species of *Cecropia*, especially *Cecropia adenopus*, which trunks are divided into chambers by transverse compartments; but Schimper has discovered a species of *Cecropia* on the Corcovado, which never contains ants, while *Cecropia adenopus* and others, as soon as they have grown somewhat large (1 year old), are always inhabited by *Azteca instabilis*. The following is now further ascertained:—

The pregnant females of *Azteca instabilis* seek out for themselves a certain very thin and soft spot in the trunk of the *Cecropia*, which always has the same situation in every internode, bore into it, and thus get into the hollow, where they deposit their brood, if they are not attacked by parasites (ichneumon flies). The opening then closes, but is subsequently opened again by the worker ants. This thinned spot is an adaptation of the plant to the ant; it does not occur in the *Cecropia*, which is free from ants (that is to say, the corresponding bud depression is not changed in texture and is not atrophied). On the underside of the stem of the leaf of *Cecropia adenopus* and others is a peculiar hair cushion,

which is constantly secreting albuminous, egg-shaped particles (Müller's corpuscles). These secretions are eagerly collected and devoured by the *Azteca;* they are one of their chief articles of food (ascertained through Fritz Müller). The *Cecropia* which is free from ants has none of Müller's corpuscles. The species of *Cecropia* are much frequented in Brazil by the leaf-cutting ants (species of *Atta*) and are terribly injured by them, as has been repeatedly ascertained by Belt and others. All those which contain *Azteca* colonies are spared, because the vicious *Azteca* pursue the *Atta* furiously and drive them away.

All this is well ascertained. The plant, by an undoubted adaptation, gives the ant food and lodging. The ant, in return, defends the plant from its worst enemy. This symbiotic relation did not, of course, arise all at once. Schimper found a *Cecropia* which is not inhabited by the *Azteca* until later, and probably also less regularly. This *Cecropia* has also, it is true, thinned boring spots, but they are not formed until later, and it has not as yet any Müller's corpuscles. Last year in Bulgaria I watched in oak woods and in old trees in general *Liometopum microcephalum*, Pz., of Europe, which lives in trees. The trunks of the trees are there, too, covered with ants, which attack fiercely all that approach them. We have not in Europe any species of *Atta* that cut leaves, but, on the other hand, we have so many more beetles and other insects which delight to destroy the old oaks. I was charmed at seeing near Aetos the finest oak forest that I have ever beheld, with real, superb giants. Almost all of them were inhabited by *Liometopum* colonies, whose running workers covered all the trunks of the oaks. I have no doubt that these fierce ants, whose carnivorous habits Emery has described, drive away the enemies of the oak. The symbiotic relations of the *Azteca* and the *Cecropia* were probably formed from these simpler relations. *Liometopum* lives only in trees; the trees, however, do not display the least adaptation to that ant.

Belt and Schimper have further proved, as to *Acacia sphærocephala*, Willd., and *A. spadicigera*, Cham. and Schlecht, of Central America, that ants of the genus *Pseudomyrma*, Lund, not only always live in the hollow thorns, but, owing to a peculiar adaptation of that plant greatly resembling that of the *Cecropia*,

find sugar and albuminous food upon them. These two species of *Acacia* possess so-called extrafloral nectaries, which furnish the ants with sugar, and on the points of their leaves Belt corpuscles rich in albumen (resembling the Müller corpuscles of the *Cecropia*), which supply them with albumen. Still, a closer direct observation of the reception of the food by the ants is as yet wanting here. The *Acacias* which are free from ants do not possess these peculiar arrangements.

(b) Imperfect symbiosis.—Belt has ascertained that the species of *Pseudomyrma* which inhabit *Acacia* thorns are fierce, warlike creatures, and keep every foe at a distance from the plant, including the leaf-cutting *Atta*, the forest-destroyers of America. The adaptation of the ant to the plant is ascertained as soon as it is proved that the respective species always lives and can thrive only in the corresponding plant. This has recently been sufficiently demonstrated in the case of *Pseudomyrma flavidula* and *Pseudomyrma belti* With all this, however, it is not yet proved that all *Acacias* inhabited by ants contribute anything on their part to this arrangement. In fact, this is not yet proved in the case of many species; in others, it is very doubtful or improbable, because, on the one hand, there are many hollow *Acacia* thorns without ants (Mr. Wroughton has sent me such from India), and because, on the other hand, many species of ants of the genera *Pseudomyrma*, *Sima*, and *Cremastogaster* frequently inhabit these thorns, and frequently make their nests in some other way. These hollow thorns with the round aperture, which the ants make use of, and which are very similar in appearance to that of the gall in Fig. 1, have been often depicted, and we do not, therefore, think it worth while to reproduce them here. I found a thorn of *Acacia fistula*, which had been brought from Somali Land by Prof. C. Keller, and which was inhabited by *Cremastogaster Chiarinii*, Emery, divided inside by pasteboard into a few small chambers. In the case of *Cremastogaster chiarinii*, Em., *C. acacia*, Forel, and *C. ruspolius*, Forel, there appears to be an adaptation of the ant to the plant.

We must now speak of the celebrated pseudobulbs of the epiphytic plants of the genera *Myrmecodia* and *Hydnophytum* of the Sunda Islands. Fig. 14 represents, in half the natural size, the photographed cross section of *Hydnophytum montanum*, which,

with other magnificent specimens of this plant and of its relative, *Myrmecodia*, which has often been sketched, was sent to me recently from Java through the kindness of my friend and colleague, Dr. Ad. Frick, of Zurich. The enormous bulb of this plant, which lives as a parasite upon trees, is always pierced by a hollow labyrinth, as represented by the cross section in our figure. Now, this hollow labyrinth, according to the observations of Forbes, Beccari, Treub, and others, as well as that of *Myrmecodia*, is always inhabited by ants, which issue from little openings near the point of departure of the roots, and fiercely attack every one who approaches, so that the natives are very unwilling to fetch these plants. Three species of ants—*Iridomyrmex cordatus*, Smith, *Cremastogaster deformis*, Sm., and *Pheidole javana*, Mayr—were found in *Myrmecodia* and in *Hydnophytum*. While, however, *Iridomyrmex* seems to make its appearance always in these plants only, *Pheidole javana* is very widespread in the Sunda Islands, and makes its nests in other ways besides. Emery is, therefore, of the opinion, which is doubtless correct, that *Pheidole* merely robs the nests of *Iridomyrmex* occasionally, and is not adapted to the plant. On the other hand, Emery regards *Cremastogaster deformis* as the constant guest of the *Hydnophytum*. In all the Myrmecodia and Hydnophytum bulbs that I received in alcohol through Dr. Frick there was a colony of the smaller, darker Javanese variety of *Iridomyrmex cordatus*, Smith (var. *Myrmecodiæ*, Emery), including males, a few pregnant females, and numerous larvæ and pupæ. All the specimens of the plant had the same hollow labyrinth, looking like a nest built by ants. It must be added that the genus *Iridomyrmex* is very closely related to *Azteca* and *Liometopum*, but comprises many species which build nests of earth.

Now, Treub has ascertained (*Annals of the Botanical Garden of Buitenzorg*, Vol. VII., 1888, p. 191) that Myrmecodia raised from seeds in hothouses and in the botanical garden of Buitenzorg develop the whole hollow labyrinth in their bulbs, to complete maturity, without the presence of ants, just as well as those which, in a state of freedom, possess ants. At the same time the plants thrive admirably. This proves that the labyrinth is produced by the plant, and not by the ants, though Beccari repeatedly found

several bundles of vessels in the compartments. Treub has, consequently, resorted to other attempts at an explanation, and has regarded these singular cavities as the breathing organs of the plant, and connected them with the interior irrigation of their web (the compartments have a very watery web), which, in view of the epiphytic situation of the plant upon trees with little foliage, is plausible. My own opinion, however, is that Beccari's observations are correct, and that the ants lend their aid by connecting some of the cavities by bored passages, as the natural cavities do not all appear to me to have a natural communication with each other, such as the ants require. Furthermore, the founders of the colony, the mother females, must first bore in. At all events, only the adaptation on the part of the ant is well ascertained—that is to say, in the case at least of *Iridomyrmex cordatus*, which finds its exclusive, beautiful, and secure dwelling in the plants of the genera *Myrmecodia*, *Hydnophytum* (and *Dischidia* ?). Botanists say that these plants furnish no special food to the ants, at least nothing has been found corresponding to the Müller's corpuscles of *Cecropia*. Since, however, most of the *Dolichoderi* keep no plant lice, but lick up the secretions of plants, or devour insects, a closer investigation of the mode of feeding of *Iridomyrmex cordatus* would probably bring some interesting facts to light. Besides, Treub's observations do not prove by any means that the plant does not form the labyrinth for the purpose of serving as a dwelling for the ants. The fierce inmates certainly afford it protection against its enemies.

We must investigate, as Schimper did for *Cecropia*, whether there are kindred species of plants, not inhabited by ants, with or without similar labyrinths. It remains surprising enough, in spite of Treub's later explanation, that so small a plant forms such a colossal bulb, with such cavities, to which a particular species of ant has so evidently adapted itself. It seems to me that the possibility of an adaptation on the part of the plant cannot yet be decisively denied, and that we should await further investigations into the biology of *Iridomyrmex cordatus* and *Cremastogaster deformis*. The fact that in the botanical garden at Buitenzorg Myrmecodia thrives without *Iridomyrmex* (Treub) proves nothing, because, in the first place, the conditions of the struggle for

existence are entirely different there from those of the primeval forest; and, in the second place, because other ants frequently take possession of their dwellings in the Myrmecodia bulbs, and act as their representatives. Treub found no dangerous foes of Myrmecodia in the botanical garden, but in the forest it can be eaten or otherwise destroyed by mammals or other animals which are kept at a distance by the ants. Scepticism is necessary and good, but denial and rejection are not good without sufficient reasons.

In a shrub in Borneo, *Clerodendron fistulosum*, Beccari, Beccari constantly found a *Colobopsis*, which Emery has named *Colobopsis clerodendri*. Here the plant, which, like the *Cecropia*, has hollow internodes, likewise forms a round, attenuated spot in its walls, which is bored through by *Colobopsis*, and serves it as a door. The plant also possesses innumerable extrafloral nectaries (that is to say, glands producing a sugary liquid, which lie, not in the flowers, but in other places). Still, I am not yet entirely convinced, in this case, that there is an adaptation on the part of the plant, because the species of the genus *Colobopsis*, so far as hitherto known, are shy and cowardly, and would, consequently, furnish no protectors to the plant. The similarity of the shape of the head of the soldier of this species seems to me to indicate that he stops up the round opening of the nest in the stalk of the Clerodendron, with his head, in the same manner that the soldier of our European *Colobopsis truncata* stops up the door of his wood nest. All investigations on this subject, as well as on the ant's mode of feeding, are still wanting.

There are, besides, a number of similar incomplete or doubtful relations, noticed especially by Beccari, as, for example, that of the palms of the genus *Korthalsia* to *Camponotus hospes*, Emery, and *korthalsiæ*, Emery; that of plants of the genus *Triplaris* to various ants which inhabit their stalks, etc.; but minute investigations of them are still wanting. The future will yet bring us many surprises.

(c) Casual relations.—We have already become acquainted with these in that kind of nest in which the ants make use of natural cavities. Hollow acacia thorns are also frequently used as dwellings by ants which elsewhere make their nests in an entirely

different way. Thus, Mr. Wroughton once, in an exceptional case in India, found *Sima nigra*, Jerdon, living in an acacia thorn.

7.—Compound Nests.

In the *Communications of the Swiss Entomological Society*, Vol. III., Part 3, 1869 ("Observations on the Habits of *Solenopsis fugax*"), I first called attention to the fact that two hostile species of ants can live in nests which are regularly intercalated. In my *Fourmis de la Suisse* (1874), I showed that such relations occur very frequently and more or less accidentally among many species of ants, especially under stones that are well adapted to nests and greatly in demand; while, in *Solenopsis fugax*, Latr., "double nests" form a very ordinary, in fact, the most ordinary, occurrence, at least in our meadows. Wasmann (*The Compound Nests and Mixed Colonies of Ants*, Münster i., W., 1891, Aschendorff's) has corroborated and supplemented my observations on this subject. Instead of the name "double nests," used by me, he has introduced the more correct expression, "compound nests" (to be translated into French by "nids composés"). In fact, these nests are not unfrequently threefold, and even fourfold—that is to say, the nests of from three to four different and hostile species of ants are built into each other, without, however, having any open communication with each other. If the partitions are destroyed, war ensues immediately. The worker of *Solenopsis fugax* is a puny, yellowish ant, hardly two millimetres in length, but the females grow to an imposing size, and look like giants by the side of the workers. This species is in the habit of digging its nests in the thick walls of the nests of the ants of the larger species, and in such a manner that, wherever there is room, large halls are constructed (Fig. 6, *S*), in which the females and the males are comfortably lodged with their large pupæ and larvæ, while small passages connect these halls. Extremely small passages, not visible in the figure, afford the workers exclusively admission to the chambers of the host ant (Fig. 6, *For.*). According to my observations and those of Wasmann, *Solenopsis fugax* lives like a thief and little robber, at the expense of its involuntary host. The little workers make their way through extremely small passages to the pupa and larva

heaps of the large ants and devour them from underneath without being seen, thanks to their small size. They also devour openly the forage supplies, as well as the dead and sick individuals, of the larger species (mostly *Formica fusca*, L., but also *Formica rufa*, *F. pratensis*, *F. sanguinea*, *Polyergus rufescens*, *Lasius niger*, etc.)

Fig. 6 represents a fragment of a double nest of *Formica fusca* and *Solenopsis fugax* from the Zurich Mountain. By means of dissolved shellac, which I poured upon the nest in fine weather, and then allowed to dry, I succeeded in making it firm enough to be able to take it out without injuring it. The fine-grained, polished interior walls of the *Solenopsis* cavities are seen, in contrast to the coarse-grained and more spacious *Formica* chambers. As the ants take up the moist earth with their mandibles in the form of small lumps, and then work it into shape with their jaws and forelegs, in order to construct their masonry with it, and as, moreover, the large *Formica* works with much coarser particles than the puny *Solenopsis*, the different character of the walls is at once explained.

I have already explained the frequent occurrence of imperfect, more accidental compound nests of other species of ant, by ascribing them to the acquisition of favourable localities, especially the underside of stones. From this competition frequently arise very murderous underground wars, which I have often watched. I have noticed closely, in glass apparatus, how they are carried on. The ants mine toward each other. A battle begins where their work happens to meet. The conqueror forces his way into the gallery of the conquered. The latter, however, hastens, after he has retired a few millimetres or centimetres, as the case may be, to stop up his gallery thoroughly with earth. The victor does not then, by any means, always succeed in again finding the entrance to it, but, in many cases, mines by the side of it, and thus partial interlappings of the nests arise. The galleries of *Solenopsis fugax* are often broken through by the large ants. The little robbers are, however, in the first place, very courageous and combative; and, in the second place, they know how to mine rapidly and how to barricade rapidly, and by this means to make a skilful use of all the partitions, as I have been enabled to observe directly in the glass nest. The digging and fighting spirit is at its highest pitch

among the ants in the first half of the summer, when the nests have to be enlarged for the brood. It then ceases, and truces follow; in the autumn there is abundant space for all, and peace prevails. It is not without reason that the females and males of *Solenopsis fugax* do not swarm until September, when the swarming-time of their host ant (July and August) has long been past. They can then, in spite of their size, go to the upper surface of the nest and swarm undisturbed, as I have seen myself, whereas they could not have done so earlier without great danger.

A peculiar variety of the compound nest is formed by the dwelling of the guest ant, *Formicoxenus nitidulus*, Nyl., with *Formica rufa* and *Formica pratensis*, which I first discovered in a fragmentary condition, and which Adlerz subsequently found and described more fully. *Formicoxenus* hunts the large *Formica*, and even follows it up closely throughout its changes of abode, as Wasmann first noticed, and as I have verified. By *Formica*, on the other hand, it is merely tolerated and superciliously ignored. The peaceable guest constructs in the walls of the nest of its large host ant little chambers and passages, which are, however, only imperfectly closed, and open freely into the chambers of the *Formica*. In these little chambers lie the brood of the *Formicoxenus*. The *Formicoxenus's* mode of subsistence is still unknown.

8.—Nests of Mixed Colonies.

The mixed colonies of the slaveholding ants and parasite ants (*Polyergus rufescens*, Latr., *Strongylognathus testaceus*, Schenk, and *S. huberi*, Forel, *Anergates atratulus*, Schenk, *Xenomyrmex stollii*, Forel) have nests which always display the architecture of the working ant (slave or host), and have no further interest for us here. When *Polyergus rufescens* seizes *Formica rufibarbis* and keeps it as its slave, its nest resembles a larger nest of that species; if, on the other hand, it enslaves *Formica fusca*, its nest looks like the nest of *Formica fusca*, because the so-called slave or auxiliary ants are the only builders.

The case appears to be somewhat different in the rare, natural, fortuitous mixed colonies (*Formica pratensis* or *truncicola* or *exsecta*, with *Formica fusca*; *Tapinoma erraticum* with *Bothriomyrmex meridionalis*) discovered by me (*Fourmis de la Suisse*), as

well as in *Formica sanguinea*, Latr., which almost always keeps slaves, but notwithstanding also work themselves. Here the nest assumes a mixed architecture, as both species of ant work on it, each in accordance with its instinctive art. And yet they do not interfere with each other. Each species understands how to combine its work harmoniously with that of the other, although the methods of the two are often very different, as, for instance, with the mason ants, *Formica fusca* and *Formica pratensis*, which work more like carpenters with their little branches and cross-pieces. *Fusca* unites the wooden rafters of *pratensis* by means of moist earth, and the whole lasts very well. I have also caused many artificial mixed colonies to be founded between *Formica sanguinea* and *F. pratensis*, etc., have even discovered naturally established colonies of these two latter species, and have investigated their mixed architecture.

9.—Migratory Nests.

Belt (*The Naturalist in Nicaragua*, 1874) was again the first to discover the hitherto unknown nest of the American migratory ants (*Eciton*). He found in the forest an immense ant ball, from which all the robber columns issued, and in which all the brood lay. Here was a genuine nomad nest, a living nest without a house. Sceptical as we had been with regard to the other discoveries of the genial Belt, we remained so respecting this one, too, until I succeeded, in the year 1885, in interesting Fritz Müller's younger brother, Dr. Wilhelm Müller, who was residing at that time at Blumenau with his brother, in this question. Dr. W. Müller has published the results of his very interesting observations in the first volume of Kosmos (*Observations on Migratory Ants*, 1886, p. 81). That which bears upon our subject may be summed up as follows: The larger species of *Eciton*, which have eyes (*hamatum*, F., *foreli*, Mayr, *quadriglumis*, Halid. [= *legionis*, Sm. = *lugubre*, Roger]. etc.) do not build or excavate any nests. They live a wandering life and merely occupy with their extremely numerous colonies spacious, naturally sheltered places, such as hollow trees or shrubs, in which they live rolled up together in immense clusters (one cluster of ants and brood, measured by Dr. W. Müller, which did not compose half the colony, measured in an

etherised state 5,600 cubic centimetres). The larvæ and pupæ first collected by Dr. W. Müller and examined by me lie at liberty among the ants, and are carried by them. The robbing expeditions are undertaken in the daytime, and the booty is carried to the migratory nest, where it serves chiefly as food for the larvæ. When one locality has been sufficiently pillaged, the whole colony migrates to another resting place. These latter migrations with bag and baggage—that is to say, with the brood—takes place exclusively at night.

Far less is known about the nests of the blind species of *Eciton* and the entirely blind migratory ant genera, *Dolyrus* and *Ædnictus*, whose workers had previously, like the male of *Eciton (labidus)*, been classed as separate genera (*Typhlopone*, Westw., and *Typhlatta*, Smith) because their connection with the previously described males was not yet known. I have myself seen *Dorylus juvenculus* at Gabés, South Tunis, hunting underground. The winged males of *Dorylus juvenculus*, Fab. (*badius*, Gerst.), *Eciton hetschkoi*, Mayr, and *Ænictus wroughtonii*, Forel, have been seen creeping out of the ground in company with workers and flying away. The very nest of *Dorylus helvorus* was dug up by Tremen, who found the female. Nothing more definite, however, is known. Are the plundered nests of other ants used for the moment as migratory nests? Are there here nocturnal migrations, too, and not robbing expeditions only? The future must tell us. At all events, judging by the observations made up to this time, including my own, *Dorylus* and *Ænictus* appear to prefer the neighbourhood of human habitations, and to fight underground with other ants.

10.—Road-Building.

Certain European ants—*Formica rufa*, *F. pratensis*, and *Lasius fuliginosus*—build genuine roads in our meadows. The finest and best finished are those of *Formica pratensis*, De Geer. A meadow, as has already been said, is a primeval forest to the ants. If the ants are, like *Formica pratensis*, rather large, and if they are compelled, like that species, to drag home all kinds of timbers as building materials, as well as animal booty, a meadow, which otherwise furnishes them with the finest hunting grounds, presents terrible obstacles. *Formica pratensis* is awkward; we need only

notice what inexpressible difficulty it has in making its way with a load through the thicket of blades of grass in a meadow, how constantly the load is getting wedged between them, and what incredible patience and perseverance the insect displays in the effort to go forward to understand the object of the roads. The road-building of *Formica pratensis* presents one of the most wonderful displays of animal instinct that I know of. Several such roads radiate with great regularity from one of the larger nests of this species lying in a meadow; I have counted from three to eight and even twelve of them (so large a number is rare and occurs only in the case of very large nests). It can be seen that these roads lead mostly to trees or shrubs on which the ants climb up in multitudes in order to milk the plant lice. The road itself is kept very clean, is from 2 to 4 centimetres in width, and is made more or less concave laterally. Not only is no movable object allowed upon it, not only is it kept always clean and in good order, but the ants, with the expenditure of incredible toil and strength, saw off with their mandibles every blade of grass that attempts to grow in the road, as they previously sawed off all those which were in existence when it was first constructed. Where the tufts of grass are too thick and strong, they go around them, it is true; but the roads usually run comparatively straight to their destination. Many of them are gradually lost in the grass; but as a rule they can be followed to a distance of twenty, thirty, forty, and in many cases fifty metres from the nest. One must watch long, closely, and above all in the spring, to see and understand the road building, and to avoid the impression that the road, as certain authors have thought, comes into existence of itself through the footsteps of the ants. These roads are very numerously frequented. All the building materials and forage are first despatched to the nearest road, so that they may be carried comfortably from there to the nest. As *Formica pratensis* has very defective powers of smell, and is not skilful in finding its way, the roads are also of great advantage to it in this respect. There are only two directions on them, and it is no longer compelled to search laboriously for the right way. It can be seen, too, how rapidly and confidently the ants move to and fro on their roads, in contrast to their behaviour in the grass. (Com-

pare Forel, *Collections of Swiss Zoology*, Vol. IV., No. 4, 1888.)

The agricultural ants of Texas (*Pogonomyrmex barbatus*, Smith, *P. molefaciens*, Buckley) make a large clearing around their nests, according to Lincecum and Mc.Cook, and numerous roads, in addition, by sawing off the blades of grass, like our *Formica pratensis*.

11.—Review—The Ant World—Landscape Types of the Ants' Nests—Polycalic Colonies.

Even among us in Switzerland, a close investigation of the meadows, the dry declivities of the mountains, the clearings of the woods and thickets suffices to show us speedily that almost everything is invaded by the structures of ants. Where there are no actual nests there are underground passages and galleries, open roads, covered ways, or, at least, the inhabitants of neighbouring nests, who are scouting around and contending with one another for the possession of the plants containing plant lice and cochineal kermes, of the trees, the flowers, and the insect plunder. I have even seen young birds which had just slipped out of the nest killed and devoured by *Formica pratensis* in spite of the frantic rage of the parent birds. The ants certainly, no less than men, fancy themselves the lords of creation, for, thanks to their social organisation, their numbers, and their courage, they have few foes to fear; their most formidable enemies are always other ants, just as men are for other men. In the tropical world the struggle for existence is much fiercer than with us, and the ants, with their immense number of species, play a much more important part. Their nest structures there, too, are correspondingly far more varied, and display far more singular and complicated adaptations as the results of the fight for life. The future will develop many still more astonishing discoveries.

We will now only give a glance at the most ordinary ant structures with respect to the nature of the ground.

In the meadows we find, above all, the mound structures of earth, but side by side with them the mixed mounds of *Formica pratensis*, *sanguinea*, and *pressilabris*, together with pure excavated nests. On detritus and declivities, we find chiefly nests under stones, and the same upon mountains generally. In the forest we

find the mighty mounds of *Formica rufa*, *exsectoides*, and *exsecta*, frequently gathered into large, united kingdoms, containing many nests (polycalic colonies), and also the tree nests of *Lasius fuliginosus*, *L. brunneus*, *Camponotus herculeanus*, *Liometopum microcephalum*, etc. Genuine—that is to say, free—tree nests of pasteboard or web in the boughs of trees do not occur in Europe. Lastly, in the forest clearings, the edges of the woods, and in thickets we find a rich mixture of the three above-named landscape types with respect to ants' nests. The meadow type, the forest type, and the detritus or declivity type are here mingled pell-mell.

The nest structure in the desert, as I have been enabled to learn by observation in southern Tunis, forms a peculiar type. There all is excavated in the sand. There are neither mounds nor stones, but at most hillocks of sand around the openings of the nests.

My object has been merely to give, by the aid of drawings, a clear view of our present knowledge of the nest-building of the ants and to communicate some new facts in connection with it. I trust that I have succeeded.

To conclude, it is a pleasure to me to express my warmest thanks to my friend, Mr. Ludwig Schröter, for his successful drawings; to Professor Schröter for his kind assistance, his suggestions, and his advice; and to the persons who procured me my excellent materials, especially my friends, Mr. Wroughton, Dr. Frick, Professor Emery, Dr. Liengme, and Professor Mayr.

EXPLANATION OF PLATES XIX. AND XX.

Fig. 1.—A gall, inhabited by *Polyrhachis gerstäckeri*, Forel, from Delagoa Bay, South Africa; collected by Dr. Liengme. One-sixth less than the natural size. *A*, The gall from the outside; *op.*, the egress opening of the gall producer, used by the ants. *B*, Longitudinal section through the gall, showing the cavity and its filling of web and a half partition.

,, 2.—Longitudinal cross-section of the stalk of *Solanum auriculatum*, from Antananarivo, Madagascar, inhabited by *Technomyrmex albipes*, Smith; collected by Père Chamboué. The marrow of the stalk has been divided by the ants into chambers. Two-thirds natural size.

Fig. 3.—A leaf of *Eugenia jambolana*, the cellular tissue of which, between the two surfaces, has been eaten out by a worm, and which has then been inhabited by *Cardiocondyla wroughtonii*, Forel. Collected at Poonah, India, by Mr. Wroughton. Two-thirds natural size.

,, 4.—Pasteboard nest of *Polyrhachis mayri*, Roger, half open, showing the interior; resting upon a leaf. From Ceylon; collected by Major Yerbury. Two-thirds natural size.

,, 5.—A nest of *Leptothorax acervorum*, Fab., excavated in the cork layer of the bark of a fir; spread out flat. Cross section along the plane of the nest; an opening at *a*. From Switzerland. Two-thirds natural size.

,, 6.—Piece of a double nest of *Formica fusca*, L., and *Solenopsis fugax*, Latr., collected by me near Zurich and preserved by impregnation with shellac. Two-thirds natural size. *W.*, The plane of separation in the walls of the nest of *Formica*. *For.*, Excavations of *F. fusca* (recognisable by the coarser grain and the greater width). *S.*, Excavations of *Solenopsis fugax*, made in the walls of the nest of *Formica*, recognisable by the fine grain. *S.o.*, Openings of the passages which connect the larger chambers of *Solenopsis*.

,, 7.—Web of *Polyrhachis dives*, Sm., from the East Indies. Microscopic enlargement; Hartnack, System IX.

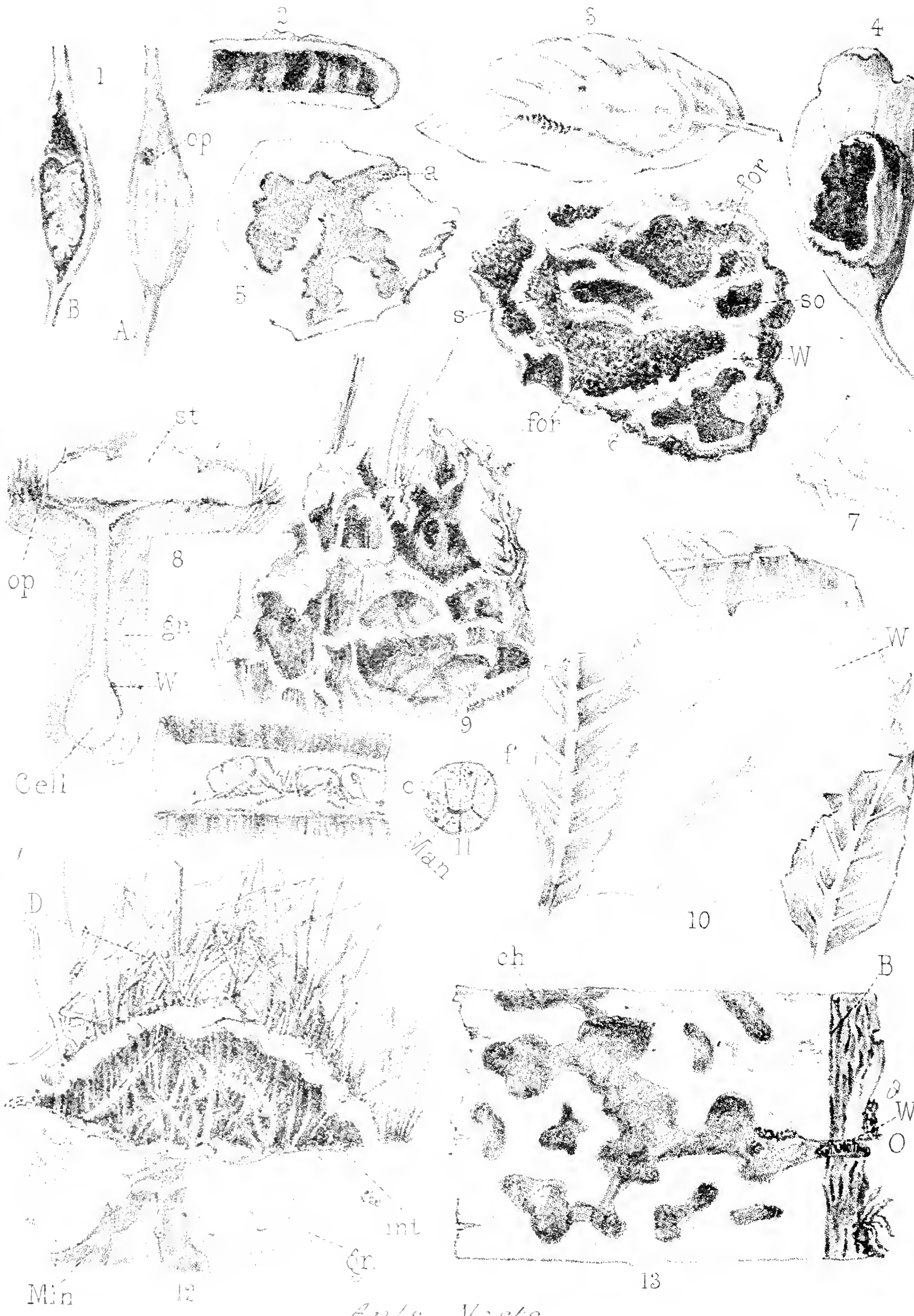
,, 8.—Nest of *Polyrhachis spinigera*, Mayr, from Poonah, India; from a sketch by Mr. R. C. Wroughton, divisional forest officer at Poonah. The nest lies under a stone, and is excavated in the ground, but is lined with a fine web, as Mr. Wroughton has repeatedly verified. The figure represents an imaginary cross section, somewhat smaller than the natural size. *St.*, The stone. *Gr.*, The ground. *W.*, The web. *Op.*, The opening for ingress and egress. *Cell*, The nest excavation.

,, 9.—Fragment of the mound of a ground nest of *Lasius niger*, L., from Zurich. We see how blades of grass and leaves are used as pillars, arches, etc., in the masonry. Two-thirds nat. size.

,, 10.—Nest web of *Œcophylla smaragdina*, Fabr., received from India, through Mr. Wroughton. We see from this fragment how the leaves of a tree are united into a nest by means of the web. *W.*, the web. Two-thirds natural size.

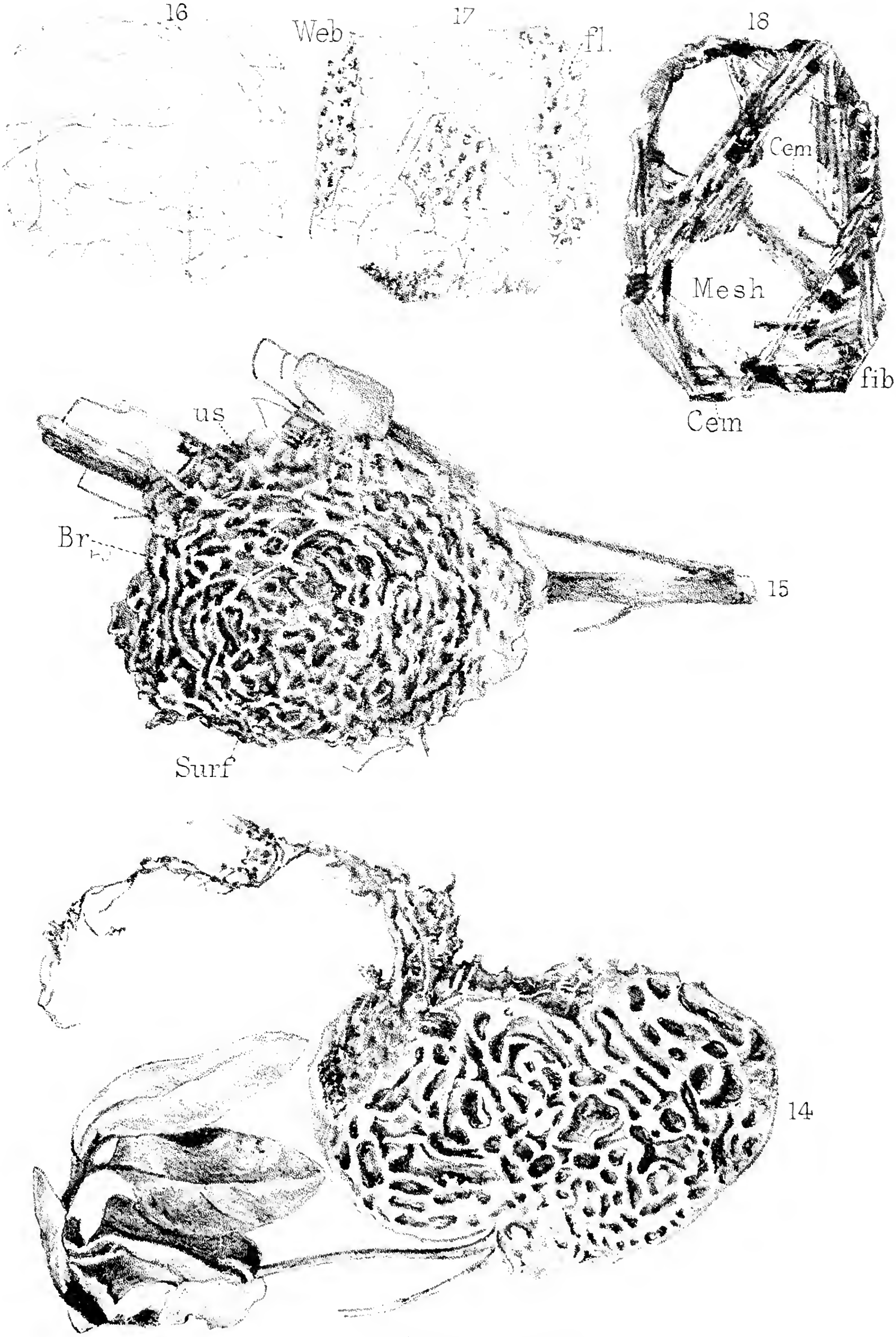
,, 11.—Flat surface of the head of a soldier of *Colobopsis truncata*, Spin., from Vaux, Canton Waadt, Switzerland, seen from the front, and magnified ten times. *Mand.*, Upper jaw. *C.*, Cheeks. *F.*, Forehead.

,, 12.—Perpendicular cross section of the nest of *Tapinoma erraticum*, Latr., from Vaux, Canton Waadt, Switzerland. Preserved by me by means of impregnation with silica. Two-thirds natural size. *D*, Temporary mound of earth. *Int.*, Interior of the nest, with its natural framework of blades of grass. *Min.*, Beginning of the underground excavated part of the nest. *Gr.*, Cross section of the ground.



Ants Nests.

F. Phillips Sc.



Ants Nests.

F. Phillips. Sc.

Fig. 13.—Cross section of a fragment of a nest of *Colobopsis truncata*, Spinola, excavated in the wood of a dead, but extremely hard pear tree. Found by me at Vaux, Canton Waadt, Switzerland. Four-thirds natural size. *Ch.*, Excavations of the nest in the wood. *B.*, Bark of the bough of the pear tree. *O.*, Opening of the nest outward, and head of a soldier of *Colobopsis truncata*, who is guarding this opening, or, rather, who is keeping it closed with his head, as with a stopper. The soldier is standing in the egress passage, which is seen in cross section. *W.*, Two workers of *Colobopsis truncata*, one in the nest, the other outside, hurrying to the entrance, where the soldier, drawing back, will make room for him for a moment.

,, 14.—Cross section of the pseudo bulb of *Hydnophytum montanum*, received from Java through Dr. A. Frick, of Zurich. Photographed one-third of the natural size. The stalk, the leaves, and the root of the plant are also seen (see text).

,, 15.—Pasteboard nest of *Dolichoderus bituberculatus*, Mayr, on the bough of a tree. Received from Bangkok, Siam, from the late well-known turner, Mr. Sigg, of Zurich. In order to show the interior labyrinth, a portion of the nest has been removed by a flat, perpendicular cut. Photographed one-third of the natural size. *Surf.*, Surface of the cut and inner labyrinth. *U.S.*, Natural upper surface of the nest. *Br.*, A small branch of the main bough, cut through and inclosed in the nest. The nest rests upon the main bough.

,, 16.—Web of *Polyrhachis spinigera*, Mayr, from Poonah, India; received from Mr. Wroughton. Microscopic enlargement; Hartnack, System IX. (Compare Fig. 8, Gesp.)

,, 17.—Nest-wall of *Polyrhachis jerdonii*, Forel, from Ceylon; received from Major Yerbury through Mr. Wroughton. Microscopic enlargement; Hartnack, System VII. *Fl.*, Small flakes of vegetable matter. *Web*, Spun net of the ants, by means of which these flakes are joined together in a web.

,, 18.—A piece of the nest pasteboard of *Dolichoderus bispinosus*, Oliv., from tropical America; received through Professor Emery. Microscopic enlargement; Hartnack, System IV. *Fib.*, Vegetable fibres of *Bombax ceiba*, L., of which the nest pasteboard is composed. *Cem.*, Ant cement or lac, by which the vegetable fibres are glued together or fastened (of a bright yellowish or brownish colour). *Mesh*, Empty meshes left by the nest walls between them.

,, 19.—Represents a "soldier" standing at the door of egress. See text, p. 357.

N.B.—All the figures, except Fig. 8, were drawn or photographed (Figs. 14 and 15) from nature by Mr. L. Schröter. I myself only drew Fig. 11 and the ants in Fig. 10.

The originals of Figs. 1, 2, 3, 4, 7, 10, 14, 15, 16, 17, and 18 are in my collection; those of Figs. 5, 6, 9, 12, and 13 are in the entomological collection of the Museum of the Federal Polytechnikum (my former collection of European ants' nests).

British Hydrachnidæ.

BY CHARLES D. SOAR. Part IX. Plate XXI.

Genus XII.—*Midea* (Bruzelius).

1854.—Bruzelius, *Beskr. ö. Hydrachn. som. forekommer i. Skane*, p. 35.

THE following is a general description of this hydrachnid :—Body, hard-skinned, with a finely granulated surface ; on the dorsal surface is a depressed line placed very close to the margin. The exterior of the inner portion of the dorsal surface is marked very conspicuously with twelve dermal glands arranged in four sets of three. The legs are well supplied with swimming hairs. On each side of the genital fissure are numerous genital suckers. The Epimera form one group.

Midea orbiculata (Müller).

1776.—*Hydrachna orbiculata.* O. F. Müller, *Zool. Dan. Prodr.*, p. 190, N. 2266.

1781.—*Hydrachna orbiculata.* Müller, *Hydrachnæ*, etc., p. 55, Tab. VII., Figs. 3 and 4.

1793.—*Trombidium orbiculatum.* J. C Fabricius, *Entom. Syst*, ii., p. 405, N. 30.

1805.—*Atax orbiculatus.* J. C. Fabricius, *Syst. Antliatorum*, p. 371.

1854.—*Midea orbiculata.* Bruzelius, *Beskr. ö. Hydrachn. som. forek. i. skane*, p. 36, Tab. iii., Fig. 5.

1880.—*Midea orbiculata.* C. J. Neuman, *Sveriges Hydrachnider*, p. 55, Tab. xi., Fig. 1.

1894.—*Midea orbiculata.* Piersig, *Zool. Anz.*, No. 449, p. 215.

On referring to Müller, Pl. VII., Figs. 1—4, will be found two mites figured, which Müller has named *Hydrachna elliptica* and *Hydrachna orbiculata*, which are no doubt two mites of the same genus (*Midea*). If we compare the mite now under consideration with Müller's, Figs. 3—4, I do not think we can come to any other conclusion than that these mites are identical. *Midea orbiculata* is nearly round ; the impressed line is near the outer

margin; in fact, both in dorsal and ventral surface, the figures of Müller's quite agree with our own. I mention this because Köenike in 1881 describes and figures a mite of this genus in the *Zeitschrift f. Wissenoch Zoologie*, XXXV., B.A., p. 600, Pl. XXX., Figs. 1—6, which he calls *Midea elliptica* (Müll.), the name given by Müller to the other mite, Figs. 1 and 2 on Pl. VII. of his work. On looking carefully at Köenike's figures, I cannot help thinking it is the same mite as our own. It is nearly circular, the depressed line is near the margin, and in all other respects is like the male, as we know it, of *M. orbiculata*. Now, the figure of *M. elliptica*, as its name implies, is a longer-shaped mite, according to Müller, and differently marked. The depressed line is much nearer the centre of the body, as is the case in *Arrenurus*.

Average length of body, about 0·64 mm.; width, about 0·58 mm.; the first leg, 0·28; the fourth leg, about 0·68 mm.; palpus, about 0·16 mm. Body nearly circular, with a depressed line in dorsal surface. On the surface of the inner portion of the dorsal covering are twelve dermal glands, arranged in four sets of three (see Fig. 5). Legs similar to other water mites, well supplied with swimming-hairs. Palpi, five joints, the fourth being the longest.

It should always be remembered that the colouring of these creatures is due to two causes:—first, the colouring pigment in the skin; secondly, the contents of the body. In no other mite that I have observed at present is this more apparent than in *M. orbiculata*. The outside margin is yellow and green. The inside portion of the dorsal plate is blue, white, purple, and red. This varied colouring is due to the two causes just mentioned. The skin is blue, with a large white patch on the anterior portion; under this in the body is a large patch of bright red (due, no doubt, to the contents of the stomach). This, being seen through the blue, undoubtedly give it a purple colour, where seen through the white part the bright red is observed. These colours are all very brilliant and must be seen to be appreciated, it being impossible to give any idea of them in a black and white drawing. The ventral surface is yellow, with green patches. Legs and palpi a pale straw colour, Eyes a bright red. The little spots on the back (see Pl. XXI., Fig. 5) are yellow, which makes them, in the living mite, very conspicuous.

Texture: hard-skinned throughout, with a finely granulated surface. The epimera is formed of a much thicker skin, and the surface is much coarser than the other parts of the body. Eyes, two, very distinct on the outer rim of the dorsal surface (Figs. 1 and 5).

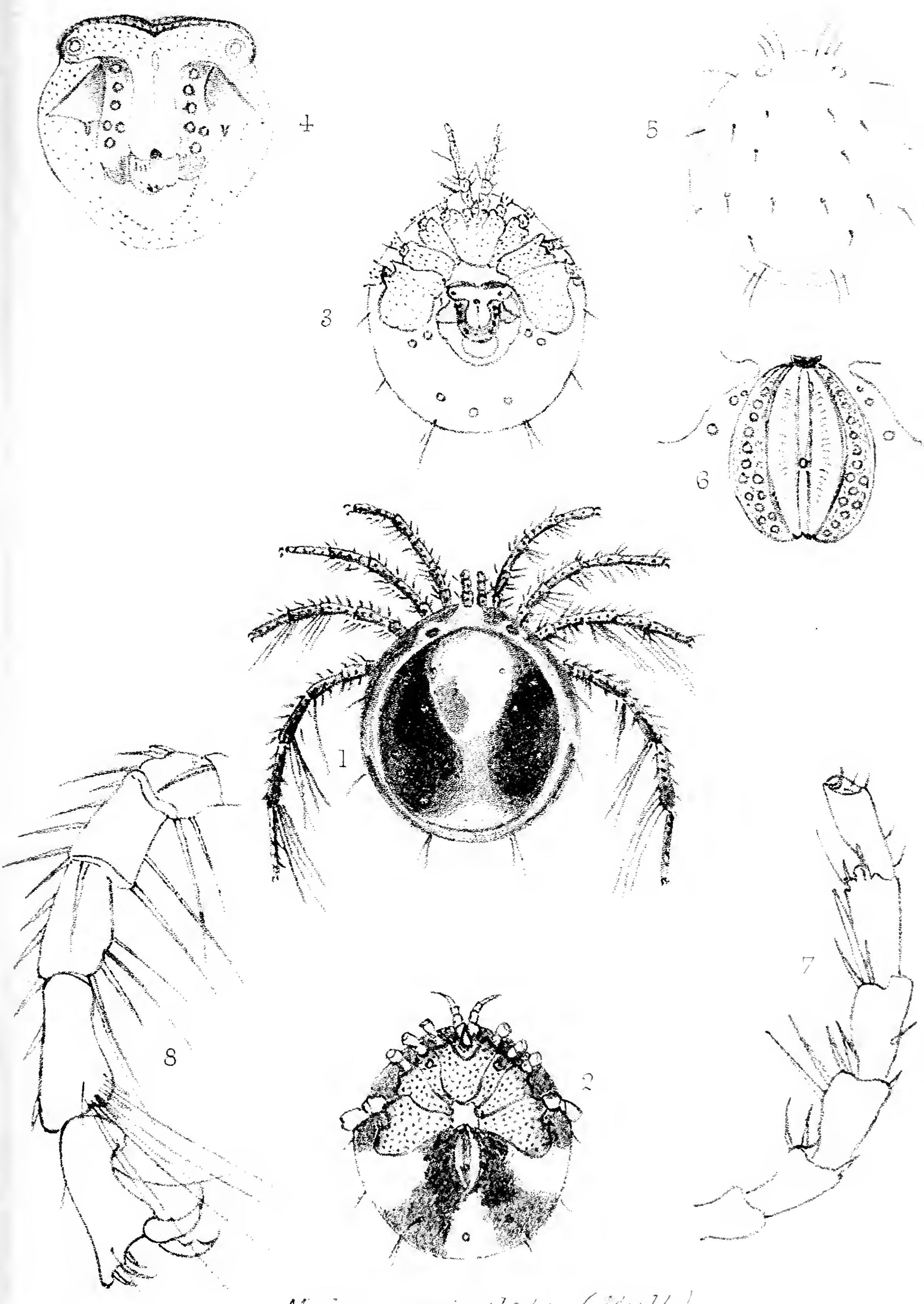
Sexual differences:—The body portion, looked at from above or from the dorsal surface, exhibits no difference in form or colour. The male may be a little smaller, but both male and female vary in size, so that this difference in size is of no intrinsic importance; but on the ventral surface a great difference can be seen (see Figs. 2, 3, 4, 6). Fig. 4 is the genital area of the male and Fig. 6 that portion of the body of the female. The third pair of feet of the male is also very different to the feet of the female (see Fig. 8).

Distribution:—Not common. I have only seen eight specimens. Dr. George, of Kirton-in-Lindsey, sent me three, Mr. Scourfield two from Epping Forest, and I have taken three myself. Although I am always collecting, yet during the last two years I have not seen any.

EXPLANATION OF PLATE XXI.

Fig. 1.—Dorsal surface of ♀.
,, 2.—Ventral surface of ♀.
,, 3.—Ventral surface of ♂.
,, 4.—Genital area of ♂.
,, 5.—Outline drawing, to show the arrangement of the dermal glands and hairs.
,, 6.—Genital area of ♀.
,, 7.—First leg of ♂.
,, 8.—Third leg of ♂.

The jaws of a true monkey have been found by Mr. Forsyth Major in the Æpyornis beds of Madagascar. From their size M. Gaudy infers that the animal was about as large as a man. The molar teeth recall *Mesopithecus* and *Semnopithecus*. In general appearance the teeth resemble those of the Old World monkeys, but their number corresponds with those of the New World. For this new fossil Mr. Forsyth Major proposes the name *Nesopithecus robertii*.—*Revue Scient.* (4), VI., 1896.



Midea orbiculata (Mull.)

Chas. D. Soar ad. nat. del.

F. Phillips Sc.

Selected Notes from the Postal Microscopical Society's Note-Books.

Diaptomus castor.

By ARTHUR HAMMOND, F.L.S. Pl. XXII.

AN Entomostracan found about April and May in weedy ponds and ditches, and on which I have been recently making some observations. These little creatures are of a reddish colour. The females measure about one-eighth of an inch; the males considerably less. The latter sex may be at once distinguished by the asymmetrical development of the long antennæ, which consist of twenty-five joints. In the male several joints are fused into one (see Pl. XXII., Figs. 2 and 3), inside which may be seen a powerful muscle acting on the succeeding joint, and capable of bending it like a hinge for the purpose of clasping the last pair of feet in the female, which are somewhat modified for this purpose.

In the latter sex both antennæ are alike. The posterior antennæ are two-branched. The mandibles, maxillæ, and first and second foot-jaws are all developed. To these succeed four pairs of feet, all two-branched, each branch having three joints, except the inner branch of the first pair, which has two only. Another and fifth pair of feet, differently formed from the preceding, completes the number of the limbs. The abdomen of the female has three joints, that of the male five, and terminates in two short branches, each furnished with five divergent setæ, forming a pretty fan.

In the last joint the cloacal orifice may be seen on the dorsal surface, the intestine extending down thereto (see Fig. 12). On either side below the head may be seen a curious triangular marking (see Fig. 4). A somewhat similar one is found on *Daphnia*, and is supposed to be the homologue of the green gland in the Cray Fish. The position of the heart is shown in Fig. 1, and it may be seen to beat rapidly. I have never been able to observe any blood-corpuscles similar to those observable in *Daphnia*, and consequently the course of the blood cannot be traced. It is probable, however, from the constant agitation of the mouth-organs, that respiration takes place in their vicinity,

this agitation causing a continual whirlpool in front of the mouth; but possibly this also may be the means of bringing food within their reach. The eye, so far as I can make out, consists of three lenses surrounding a central mass of pigment. Two of their lenses are lateral and one ventral (see Figs. 3 and 6). The eye is lodged, I believe, in a cavity, as is that of *Daphnia*, and is balanced, I think, in a similar manner. I believe it represents, in fact, the eye of *Daphnia*.

A capacious stomach may be seen just below the head, and the intestine extends to the last joint of the abdomen. The body is well provided with longitudinal and transverse muscles, the latter converging in powerful masses towards the basis of the feet.

The reproduction of these creatures presents some peculiar features. The male attaches to the female a series (four or five) of sausage-shaped bags containing the seminal secretion. These have been termed spermatophores. Some of them are seen in my Fig. 1, attached to the base of the abdomen of the female. Another is seen in Fig. 2 while yet within the body of the male. Fig. 8 shows its position while in that condition. It now exhibits a tough cuticular covering, within which lies a delicate sac occupying the whole of its cavity and filled with the spermatic fluid. In this fluid float spermatozoa in great numbers, occupying nearly the whole of the sac, except the extreme end, which is occupied with a collection of brownish granules. Fig. 9 represents one of the spermatophores attached to the abdomen of the female.

We here see that the sac containing the spermatic fluid has shrunk away from its cuticular investment, and that a cellular structure intervenes between the two. The spermatozoa are much fewer and are collected in a mass at the base of the spermatophore. The granules still occupy the extremity of the sac. Fig. 7 represents a spermatophore just previous to the final expulsion of its contents, which expulsion I was fortunate enough to witness. Only a small remnant of the sac is now seen, and this I soon perceived to be rapidly disappearing, carrying the granules with it. When it had entirely disappeared, the few spermatozoa at the base of the spermatophore also quickly followed it, and streamed out through the neck into the vulva of the female.

Strange to say, no cavity appears to be left by the disappear-

ance of the seminal sac with its contents. The cellular structure previously referred to now occupies the whole of the exhausted spermatophore, as may be seen in Fig. 7, an irregular line only serving to mark where the surrounding cellular structure has pressed in to fill up the void. It is plain that it is by the expansion of this tissue that the spermatic fluid is gradually expelled. Whether this expansion is a vital process, the cells multiplying and so pressing out the sac and its contents, or whether the cells, originally minute and occupying little space, gradually absorb water through the cuticle and so produce the same effect, I am unable to say. The spermatic fluid, of course, retains its vitality; may not the surrounding cellular tissue do the same until its purpose is served?

At *ov.*, Fig. 1, is seen a cellular mass, which on expulsion from the body when the animal is crushed assumes the appearance seen in Fig. 12, and consists of large nucleated cells. At *t*, in Fig. 2, is a delicate sac occupying the same position, and filled with minute cells, as shown in Fig. 13. The anterior extremity presents a brownish granular appearance From the manifest dissimilarity of these organs in the male and female, there can be no doubt that they are respectively the ovary and testis; the nucleated cells in the female being the ova with the germinal vesicle and the minute cells in the male being spermatic cells, within which the spermatozoa are formed.

In the brownish granular appearance in the anterior portion of the testis I think I recognise the source of the similar granules found subsequently at the extremity of the spermatophores. The ovary and testis thus described appear to be single organs, occupying a mesial position in the body, but doubtless they are really paired organs, which is, I think, the universal rule. We have seen how a pair of closely applied organs may be taken for one in the eye of *Daphnia*. The ova here originating undergo subsequent development in two lateral masses—one on either side. Here the granular yelk is formed and the ova take the dark shade seen in Fig. 1. Ultimately, they are passed into a receptacle attached to the base of the abdomen, as seen in Figs. 1 and 5, and after being carried about for some time finally fall off, their further history being to me (at least) unknown.

EXPLANATION OF PLATE XXII.

Fig. 1.—Female. 1 *an.*, the superior; 2 *an.*, the inferior antennæ; 2 *mxp.*, the second maxillipede; 1, 2, 3, 4, 5, feet; *e.r.*, egg receptacle; *sph.*, spermatophores attached to the abdomen; *h.*, heart; *ov.*, the ovary; *ova*, the lateral mass of ova; *st.*, stomach.

,, 2.—Male. The lettering is the same except *t.*, the testis.

,, 3.—Eye. Lateral view.

,, 4.—Spiral marking on carapace.

,, 5.—Egg receptacle; front view.

,, 6.—Eye; front view.

,, 7.—Spermatophore, nearly empty.

,, 8.—Ditto, full (in the body of the male).

,, 9.—Ditto, half empty. *s*, The sperm sac. (Figs. 7, 8, 9 are not drawn to the same scale.)

,, 10.—Portion of ovary.

,, 11.—Testis.

,, 12.—Abdomen. *a.*, anus (male).

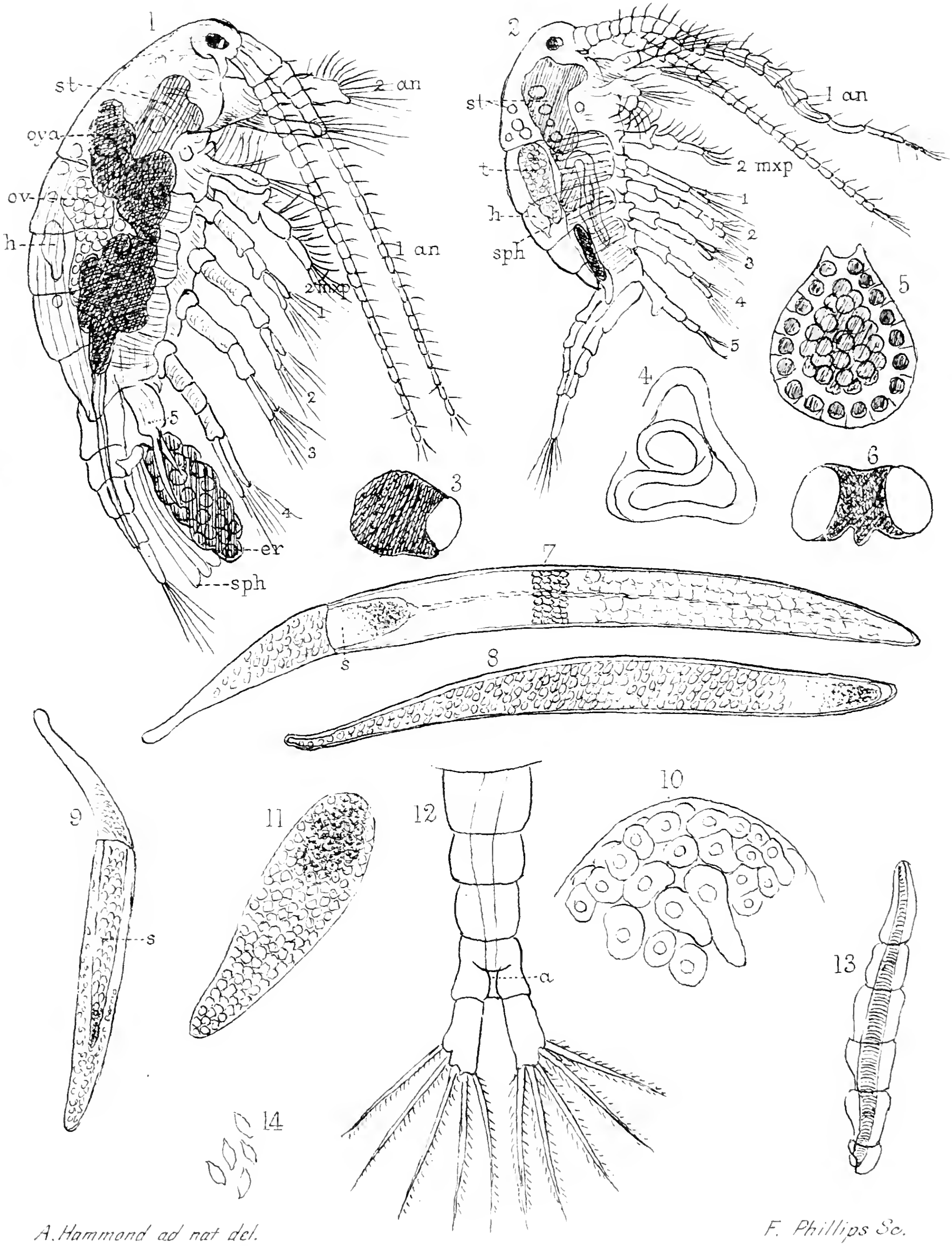
,, 13.—Consolidated joint of male antenna, with muscle.

,, 14.—Spermatozoa.

Drawn by A. Hammond.

Larva of Corethra plumicornis may in the spring be found in great abundance in our ponds, and forms an object of surpassing beauty under the microscope. It is a gnat of the family *Tipulidæ*, not *Culicidæ*, and the change of form from larva to pupa is very marked and interesting, the former swimming in a horizontal position after the manner of a fish; whereas, the latter assumes an upright position and moves in jerks upwards. The beautiful fan of hairs terminating the body in the larva is replaced in the pupa by a number of plates resembling the tail of the Cray-fish, and in this latter state the air-bladders, which serve in part to maintain the horizontal position of the larva, have quite disappeared, unless it be the two front ones, over which the head and thorax of the pupa seem to be supported. E. Bostock.

Pupa of Corethra plumicornis.—In its larva stage this is the well-known "Phantom Larva." The most interesting features in the pupa mount are the respiratory tubes, and the very graceful tail (? rudimentary wings). I can obtain no information as to the



A. Hammond ad nat del.

F. Phillips Sc.

Diaptomus castor.

final developments of this creature, beyond that it is a "Dipterous Insect," and from some of our members I hope to learn something as to the "latter end" of this interesting organism. J. HALSEY.

To cut Cells in Glass Slips.—This may be done as follows:— A hole is bored through the glass very easily with a piece of copper tube running in a lathe. The tube must be charged with emery powder and oil. A thin cover glass is then cemented on with gold size—ordinary gum may be used for this purpose, and answers the purpose very well. I often confine a live insect in this way, and view it on both sides with a Leiberkuhn or a side reflector. In this case I fasten the cover on very slightly with gum; after full inspection I usually give the insect its liberty again. Most insects possess a beauty when viewed alive that they lose after death. JAS. MACKENZIE.

Cysticercus pisiformis.—A parasite from the intestine of rabbit. *Cysticercus* appears to be a rudimentary form of *Tænia*, which attains perfect development in the alimentary canal of its host. No organs of sense except touch; no eyes. A difference of opinion exists as to evidence of digestive and circulatory systems, the mouth is usually distinct. R. PEACH.

This is probably the cystic form of *Tænia serrata*, the intestinal worm of the dog and fox. *Vide* Huxley's *Anatomy of the Invertebrates*, pp. 209—211; and Rolleston's *Forms of Animal Life*, p. 136, amongst readily accessible books. H. POCKLINGTON.

Section of Cacao-Bean, or rather a part of one of the lobes, known as a "nib." The seeds, or beans, are enclosed in a pod, about six inches long by four broad, and are arranged in rows, often five rows of six beans each, round a central axis, or stalk within the pod. The seed when shelled is found to consist of several lobes of angular form, and irregular in shape and size, which break up into "nibs." The lobes consist of innumerable minute cells, roundish, the spaces of which are loaded with grains of starch and fatty matter.

A half inch o.g. will show very distinctly the starch and fat cells. I am particularly struck with the arrangement of the starch cells. These do not appear to be spread about through the mass, but to be arranged in rows parallel with the surfaces of the lobes,

not far from the surfaces in any case. In a fissure, near the centre of the lobe, are what I take to be some much larger starch grains; they are three or four times the size of the others, and are heavily scored, reminding one of the knotted appearance of raw tapioca.

There is usually supposed to be 51 per cent. of fat, and 11 per cent. of starch in the cacao-bean, besides 7 per cent. of gum. Can the large cells I have referred to be gum?

HAHNEMANN EPPS.

Caprella linearis is popularly known as the "Skeleton Shrimp," and belongs to the sub-class LÆMODIPODA, a division of the sessile-eyed Crustacea. The sub-class derives its name from the circumstance of having the first pair of legs placed very far forward, under the throat, as it were. The abdomen is quite rudimentary, there is no carapace, and the two first segments of the thorax are amalgamated with the head, and carry the first pair of legs. Normally there are seven pairs of hooked feet in the adult animal, but in this genus the third and fourth pairs are aborted, and their place is taken by two oblong membranous sacs, which act as respiratory organs. In the female the ovisacs, containing numerous good-sized eggs, are also placed here. The *last* pair of legs are articulated on the outer end of the last body-segment, but in some species one or two minute segments may be found projecting beyond them. There are two pairs of antennæ, a larger and a smaller pair, consisting each of several joints. The LÆMODIPODA are all marine. Of the genus *Caprella* Gosse enumerates nine species, but *C. linearis* is the one most generally met with, and is tolerably common. In some large old specimens I have found numerous fine, circular crystals—probably carbonate of lime—which show brilliant colours with the polariscope.

J. H. GREEN.

Elytron of Cricket.—This object gives members an opportunity of studying the mechanism of a very curious musical instrument. In *Science Gossip* for Dec. (? 1882), is an article on the subject, which is highly interesting. The "file" consists of about 230 teeth, mounted on a ridge elevated above the surface of the elytron. The elytra are opened and shut so rapidly as to be undefinable by the eye during the operation. The shrill sound

produced by the cricket is without doubt produced by friction of the "files" of the two elytra against some other portions of the creature's body, reverberated and enforced by the "drum's" spaces on the two membranous elytra acting as such; the two lower wings are what are supposed to be the other appliances used, and in the rapid opening and shutting of the elytra, the "files" mounted on them are supposed to be rasped over the ridges rising from the surfaces of the lower wings. I would recommend those who desire to understand the operation thoroughly to read the article referred to.

There are other explanations offered of the operation of chirping, besides that given above. It appears to be the male insect only that is musical. HAHNEMANN EPPS.

Elytron of Cricket.—Referring to the note by Mr. Epps, and on close examination of the object with a high power, I should suggest that the shrill sound is produced by the vibration of the stiff hairs on the ridges of the elytron; the hairs catching each other, and on springing back producing the sound, which is increased by the expansion of the sac to tightness, in the same way as a pin stuck firmly into a table or sounding-board gives a loud tone. Imagine a pin securely fixed on the end of a drum, and caused to vibrate, the tone is greatly increased. I should imagine that the wings are raised from this moveable sac (?), and act as a deflecting board, throwing the whole sound in one direction. S. R. BARRETT.

Reviews.

L'ANNEE BIOLOGIQUE; Comptes rendus Annuals des Travau de Biologie Generale. Publies sous la direction de Yves Delage. Roy. 8vo, pp. xlviii.—732. (Paris: C. Reinwald. 1897.) Price 20 francs.

This is an important Year-Book, compiled by Prof. Delage, and a number of associate editors, giving an analysis of many hundreds of books, magazine articles, etc., relating to biological research. The methodical arrangement of the subjects and the excellent index renders this work an admirable work of reference for all who wish to become acquainted with the newest biological theories.

The editor apologises for the delay in publishing this volume, which gives a *resumé* of the work of the year 1895, but the volume for 1896 will very shortly be published, after which it is believed there will be less delay.

TRAITE DE ZOOLOGIE CONCRETE. Par Yves Delage and Edoard Herouard. Tome I., La Cellule et Les Protozoaires. Royal 8vo, pp. xxx.—584. (Paris: Librairie, C. Reinwald. 1897.) Price 25 francs.

The authors have entitled this work Concrete Zoology in contradistinction to those works which are concerned more generally with abstract theories.

After an elaborate account of the structure of the cell, the Protozoa are described with great minuteness and care. The volume is illustrated by 870 very beautiful figures in the text, the majority of which are printed in colours.

We find also a Table of the Classification of the Protozoa; a Classified Bibliography of—1, The Cell; 2, Protozoa in general; 3, Rhizopods; 4, Sporozoa; 5, Flagelles; and 6, Cells; an Index of Technical Terms; and a General Index of the Protozoa.

PLANTÆ EUROPÆÆ. Tomus II., Fasc. I. Edited by Dr. M. Gürke. 8vo, pp. 160. (Leipzic: Wilhelm Engelmann. London: Williams and Norgate. 1897.)

Volume I. of this most useful work appeared seven years ago, but the death of Dr. Richter, the then editor, rendered it very doubtful if this list of European Plants would ever be completed. Dr. Gürke has, however, undertaken to continue the work, which will be issued in parts at frequent intervals.

The name of every plant is followed by a reference to the work in which it is described, synonyms are given, and mention is made of the countries in which the plants are found.

OPEN-AIR STUDIES IN BOTANY: Sketches of British Wild Flowers in their Homes. By R. Lloyd Praeger, B.A., B.E., M.R.I.A. Illustrated by Drawings from Nature by S. Rosamond Praeger, and Photographs from Nature by R. Welch. 8vo, pp. xiii.—266. (London: C. Griffin and Co. 1897.) Price 7/6, plain; 8/6, gilt top.

The chapters in this specially interesting book exhibit, by means of familiar scenes in our own islands, glimpses of plant-life interpreted by the study of actual scenes from nature; for, as the author says, "thus only can we hope to comprehend the life of a plant or of a plant-community, and appreciate the conditions under which each species lives, and the adaptations by which each is able to maintain its position in the plant-world and fulfil its proper functions. There are 6 plates and 68 illustrations in the text.

AMONG THE WILD FLOWERS. By Rev. Henry Wood. Vol. I., Spring; Vol. II., Summer. Cr. 8vo, pp. 250. (London: Swan, Sonnenschein, and Co. 1897.) Price 1/- each.

The aim of the author of these two vols. of the "Young Collector" series has been to give simple but accurate information respecting the principal Natural Orders and Genera of our British Flora; the method adopted being to describe plants which were in bloom at the time, and to notice with these other species and genera of the same Natural Order. There are a number of good illustrations.

DIE NATURLICHEN PFLANZENFAMILIEN. By A. Engler. Nos. 146, 147, 148, 153, 154. (Leipzig: W. Engelmann. London: Williams and Norgate. 1897.)

In these numbers will be found descriptions of the Labiatæ, by J. Briquet; Hysteriineæ, by G. Lindau; Tuberineæ and Plectascineæ, by Ed. Fischer; Araliaceæ, by H. Harms; Umbelliferæ (Apiaceæ and Dolgengewachse), by O. Drude; and the Sphærialis, by G. Lindau. These parts also contain Title-pages and Indexes to Vols. III. and IV. The illustrations are, as usual, exceedingly good and very numerous. There are 81 illustrations, composed of 513 figures.

Introduction to General Chemistry. By Gustavus Detlef Heinrichs, M.D., LL.D., etc. 8vo, pp. 400. (St. Louis, Mo., U.S.A. : C. G. Heinrichs. London : H. Grevel and Co. 1897.)

The author tells us that a radical change in the methods of teaching Chemistry is greatly needed, and in the volume before us he attempts the reformation. He presents the entire science in a strictly graded course ; the principal points being determined in the order of their historic growth. The discovery of oxygen is not presented until its necessity can be understood ; the atomic theory comes last. There are a number of plates, showing Crystals, Diagrams, Apparatus, etc., besides many illustrations iu the text.

A New English Dictionary on Historical Principles. Edited by Dr. James A. H. Murray. (Oxford : The Clarendon Press. London : Henry Frowde.) Price 5/-

This part contains the words from Doom to Dziggetai, and completes the third volume. The entire portion of the Dictionary occupied by the letter D contains a total of 19,051 words, made up of 13,478 main words; 2,099 subordinate ; 1,480 special combinations ; and 1,944 obvious combinations.

The three volumes now completed of this exhaustive work—(A—E)—contain no fewer than 97,608 words ; that is to say, nearly 100,000 words, simple and compound, have thus far been dealt with. Of these, more than 72 per cent. are current and native or fully naturalised, whilst 24 per cent. are obsolete.

Of the volume just completed, 740 pages are occupied by the letter D and 488 by E.

Euclid : Books I.—IV. By Rupert Deakin, M.A. Cr. 8vo, pp. viii.—309. (London : W. B. Clive.) Price 2/6.

This is one of the "University Tutorial Series," in which the aim of the author, who has had more than 20 years' experience in teaching Euclid to large and small classes—has been to make the intelligent study of Euclid as easy as possible.

The Tutorial Trigonometry. By William Briggs, M.A., F.C.S., F.R.A.S., and G. H. Bryan, Sc.D., F.R.S. Cr. 8vo, pp. viii.—326. (London : W. B. Clive.) Price 3/6.

The subject-matter of this book is treated under the different headings. The first ten chapters deal mainly with what has been designated at Cambridge "Trigonometry of One Angle" ; the next four chapters treat of Trigonometry of two or more angles ; and the remainder of the book is devoted to Logarithms and Trigonometry of Triangles. Answers to Examples are given at the end of the book.

European Butterflies and Moths. By W. F. Kirby, F.L.S., F.E.S., etc. (London : Cassell and Co.)

Since our last notice, we have rceeived Nos. 36 to 45 of this important work. Each part contains a beautifully coloured plate, showing larvæ, pupæ, and perfect insects with their food-plants. These parts are published at 6d. each.

Roentgen Rays and Phenomena of the Anode and Cathode : Principles, Applications, and Theories. By Edward P. Thompson, M.E., E.E., etc. Concluding chapter by Prof. W. A. Anthony. Roy. 8vo, pp. xviii.—190. (New York : D. van Nostraud Co. London : E. and F. N. Spon. 1896.)

This book is divided into sixteen chapters, each paragraph being numbered, and the table of contents gives the subject of each paragraph. The book involves the disclosure of the facts and principles relating to the phenomena occurring between and around charged electrodes, separated by different gaseous media at various pressures. The specific aim is the treatment of the radiant

energy developed within and from a discharge-tube, the only source of the X rays. The frontispiece to the book is a fine portrait of Dr. William Konrad Roentgen ; there are also 60 diagrams and 45 half-tone illustrations.

THE ABC OF THE X RAYS. By William H. Meadowcroft. Cr. 8vo, pp. 189. (London: Simpkin, Marshall, and Co.) Price 4/-

The author aims at assisting two classes of readers : those who desire to add to their stock of general information, and those who wish to pursue for themselves a line of investigation and experiment in the fascinating domain of these mysterious rays.

The explanations are plainly given. Information as to choice of apparatus is also given. There are 37 illustrations.

BROMIDE ENLARGEMENTS and How to Make Them. By J. Pike. pp. 64. (Bradford and London : Percy Lund and Co. 1898.) 6d.

No. 13 of Lund's Popular Photographic Series treats in a thorough manner of the subject of enlarging. This little book is beautifully printed and well illustrated, and its size—$7\frac{1}{2}$ by $4\frac{1}{8}$ in.—makes it convenient for carrying in the breast-pocket.

PHOTOGRAPHIC LENSES: How to Choose and How to Use Them. By John A. Hodges. Cr. 8vo, pp. 142. (Bradford and London: Percy Lund and Co. 1897.) Price 2/-

This book aims to explain, as far as possible without reference to technical terms, the properties and uses of photographic lenses.

THE PHOTOGRAPHIC ANNUAL, 1897. Edited by Henry Sturmey. 8vo, pp. cxlviii.—548. (London : Iliffe and Son. 1897.) Price 2/6 and 3/6.

As usual, a vast amount of most useful information, as well as a number of beautiful plates, is here given to us, the various subjects being classified and arranged in their several sections.

LA CHROMOPHOTOGRAPHIE sur Plaque fixe et sur Pellicule Mobile. Par Louis Gastine. Cr. 8vo, pp. 172. (Paris : Gauthier-Villars et Fils.)

Chromo-photography is a method of precisely representing the continuance and succession of movements. Given an object in motion, Chromo-photography tells how quickly, how far, and how much it moves, and being a system having photography for its base, it must necessarily be a faithful method.

The system has recently undergone considerable improvements, which are fully described in the little book before us.

THE PROCESS YEAR-BOOK, Vol. III., 1897 : An Illustrated Review of all Photo-Mechanical Processes. 4to, pp. 128. (London: Penrose and Co.) Price 2/6.

We have here specimens of every description of Photo-Mechanical Process Work, including Astronomical Photography, all very beautifully executed, together with instructions which cannot fail to prove most useful to the photographer, whether amateur or professional. The full-page plates—of which there are a great number—are very fine, several being printed in colours.

Annual of the Universal Medical Sciences. 5 Vols., Royal 8vo. (Philadelphia, New York, and Chicago: The F. A. Davis Co. London: F. J. Rebman. 1896.)

These superb and exhaustive volumes contain a yearly report of the Progress of the General Sanitary Sciences throughout the World. They are edited by Charles E. Sajous, M.D. (Paris), and Seventy Associate Editors, assisted by over Two Hundred Corresponding Editors, Collaborators, and Correspondents, and are illustrated with Chromolithographs, Engravings, and Maps.

To give a list of each subject treated in these five large volumes would take up too much of our space. We deem it better, therefore, to make a short extract from the Preface, in which Dr. Sajous says:—"In the vast field before us we can, at best, but gather the salient points of what we read. The memory seizes upon the theme of a given subject, and time either allows the impression to disappear, or, by furnishing evidence of its worth, brands it as an acquisition to our knowledge. To present these salient points in a form at once intelligible and practically useful has been the aim of the Editor in elaborating what he considers the most important feature of the 1896 Annual. The Analytical Index and Cyclopædia of Treatment gives a summary of every practical article quoted in the Annual proper, and of all the criticisms introduced by the Associate Editors—the active principle, as it were, of the whole year's labours. The arrangement of this material is peculiar—a counterpart, as it were, of an international medical congress in brief, each subject being sub-divided into sections. The excerpts being arranged in careful, logical sequence, each phase of a disease is taken up in turn and each author expresses his views at the proper time. The brevity of the excerpts gives them a most striking character, and the whole, with its numerous contradictions, the overwhelming evidence adduced in favour of certain views or against others, etc., constitutes what seems to the Editor to be a most instructive combination—one, indeed, he thinks, never before placed before the profession. . . . During the preparation of the work, any very important innovation in the general field of medicine, appearing in the medical press, was noted and introduced as an editorial note, thus practically bringing the most important question up to the date of publication."

We notice, also, that the following among other improvements have been made:—1, Headings and side-headings are printed in bold, black letters. 2, All prescriptions are written out in full and in the usual form, instead of running them into the text as formerly. 3, All therapeutic subjects have been collected in the fifth volume, so as to enable the practitioner to keep it on his desk for ready reference. 4, Increase in the number of coloured plates, which are exceptionally good.

Science Progress. New Series, Vol. I., Part 4. A Quarterly Review of Current Scientific Investigation. Conducted by Sir Henry C. Burdett, K.C.B. Edited by J. Bretland Farmer, M.A., with the co-operation of a large Editorial Committee. (London: The Scientific Press, Limited.) Price 3/-, or 10/6 per annum, post free.

This part contains papers on the following subjects:—The Natural History of the Sea, by George Murray, F.R.S.; The Venoms of the Toad and Salamander, by Richard T. Hewlett, M.B.; The Red Pigment of Flowering Plants, by F. W. Keeble, B.A.; Recent Values of the Magnetic Elements at the Principal Magnetic Observatories of the World, by Charles Chree, M.A., F.R.S.; The Position of Sponges in the Animal Kingdom, by E. A. Minchin, M.A.; The Diseases of the Sugar-Cane (Part II.), by C. A. Barber, M.A.; Recapitulation, by J. T. Cunningham, M.A.; Appendix; Reviews of Books.

KNOWLEDGE: An Illustrated Magazine of Literature, Science, and Art. Price 6d.

Many of the later numbers of this magazine contain most interesting papers by Frederick Enock, F.L.S., F.E.S., etc. That in the September part is on Fairy Flies, with eight fine photographic illustrations. Astronomical papers form an especial feature of the magazine. They are always well illustrated with photographic plates.

THE WAY ABOUT SOMERSETSHIRE. By Henry Harbour. With Map and Illustrations; together with a Comprehensive County Gazetteer. (London: Iliffe and Son.) Price 1/-

A book of 230 pages and very convenient for the pocket; will be found a most useful companion for the tourist. It is nicely illustrated, and the descriptions of places are correct so far as we have tested them.

THE VICTORIAN ERA: A Graphic Record of a Glorious Reign. By Robert E. Anderson, M.A., F.A.S., etc. Cr. 8vo, pp. vi.—248. (London: Geo. Newnes, Ltd. 1897.) Price 2/-

A beautifully illustrated little book of thirty-seven chapters, giving an account of the Queen from her youngest years to the present time; the British Empire, Colonies, etc.; Sixty Years of Progress; and the Diamond Jubilee. With each copy of the book is presented the particular Photograph of Her Majesty the Queen, selected and signed by herself.

THE SWAN FOUNTAIN PEN.—Messrs. Mabie, Todd, and Bard, 93 Cheapside, London, have very kindly sent us one of their Fountain Pens, which writes in a most satisfactory manner. It consists of a reservoir holding a sufficient supply of ink to last for several days, and a solid gold iridium-tipped pen. We find writing with this pen quite a pleasure; it travels very smoothly over the paper. One of our friends tells us he has written with one for several years, and finds it writes better now than at first. The price is from 10/6 upwards.

LADY COOK'S TALKS AND ESSAYS. Vols. I., II., III., IV. Cr. 8vo, pp. 87, 99, 147, 133. (London: The Roxburghe Press.) 6d. each.

These little paper-cover volumes contain a number of forcibly-written Essays on various subjects of a social nature. The Essays are fifty in number.

THE CHRISTIAN WORLD PULPIT. Vol. LI. (Jan. to June), 1897. 4to, pp. 412. (London: Jas. Clarke and Co.) Price 4/6.

A volume consisting of sermons, addresses, etc., by many authors on a great variety of subjects suitable for Sunday reading.

The following came to hand too late to notice:—

INSTITUTES OF ECONOMICS: A Succinct Text-Book of Political Economy for the use of Classes in Colleges, High Schools, and Academies. By Elisha B. Andrews, D.D., L.L.D. Cr. 8vo, pp. xii.—227. (Boston, U.S.A.: Silver, Burdett, and Co. 1897.)

THE MECHANICAL ARTS SIMPLIFIED: A Work of Reference for the use of Architects, Builders, Blacksmiths, Book-keepers, etc. etc., and Business Men generally. Ice-making and Electricity. Compiled by D. B. Dixon. Appropriately illustrated. 8vo, pp. 497. (Chicago, U.S.A.: Laird and Lee. 1897.)

Received since going to press:—

THE RÖNTGEN RAYS IN MEDICAL WORK. By David Walsh, M.D.Edin. With an Introductory Section upon Electrical Apparatus and Methods. By J. E. Greenhill. 8vo, pp. 144. (London: Bailliere, Tindall, and Cox. 1897.)

In this work the author deals with the present practical scope of the Röntgen Rays so far as physicians and surgeons are concerned. He treats the matter in a systematic manner, and points out limitations and possibilities as well as records actual achievements. In the first portion of the book the author treats of Electrical Apparatus and Methods, and in the second Medical and Surgical Applications under the following heads:—*A*, Surgery; *B*, Dental Surgery; *C*, Medicine; *D*, Obstetrics and Gynæcology; *E*, Legal Medicine; *F*, Anatomy; *G*, Physiology; and *H*, The Rays in Veterinary Surgery. There are 58 illustrations, and in the Appendix is given Prof. Röntgen's Original Communication to the Würzburg Physico-Medical Society in Dec., 1895.

THE HISTORY OF MANKIND. By Prof. Friedrich Ratzel. Translated from the Second German Edition by A. J. Butler, M.A.; with Introduction by E. B. Tylor, D.C.L., F.R.S. With coloured plates, maps, and illustrations. Vol. II. Royal 8vo, pp. xiv.—562. (London: Macmillan and Co. 1897.) Price 12/- net.

So good a judge as Prof. Virchow wrote of this work on its first appearing that since the time of Pritchard and Waitz no such extensive attempt had been made to represent our knowledge of the lower races of mankind, immensely augmented as this has been by the researches of travellers, the exhibition of savages in Europe, and the information opened to the public by the great museums.

In this volume (Vol. II.) the description of the American-Pacific Group of Races is concluded with an account of the Americans. 1, The Cultured Races of America; 2, The Ancient Civilised Races of America; and 3, The Arctic Races of the Old World. Book III. treats of the Light Stocks of South and Central Africa; and Book IV., The Negro Races.

In this volume there are two maps, showing the Civilisations of Africa and the Races of Africa. There are ten fine coloured plates and many hundreds of illustrations in the text.

GLIMPSES INTO PLANT LIFE: An Easy Guide to the Study of Botany. By Mrs. Brightwen, F.E.S. Cr. 8vo, pp. 351. (London: T. Fisher Unwin. 1897.) Price 3/6.

Those who have read Mrs. Brightwen's charming little books, "Wild Nature Won by Kindness" and "More about Wild Nature," will be charmed with the one now before us, in which she tells us about the life-history of the different plants. Here she helps us to enjoy spending hours in a garden, learning to understand the structure of plants, and enabling us, when we see a bud, or a root, or a twig, to know what the history of that object is, how it comes to have the shape it takes, how it developes into its present condition, and what its next form will be. The careful reading of this book will help to turn a country walk from a useless lounge to a lively object-lesson, delightful from beginning to end. There are nearly 100 good illustrations.

THE MECHANICAL ARTS SIMPLIFIED. By D. B. Dixon. 8vo, pp. 497. (Chicago: Laird and Lee. 1897.) Price $2·50.

This is a comprehensive treatise on Electricity, Hydraulics, the Indicator, Ice-making, etc., and certainly gives a large amount of information on almost every conceivable subject.

INSTITUTES OF ECONOMICS : A Succinct Text-book of Political Economy for the use of Classes in Colleges, High Schools, and Academies. By E. B. Andrews, D.D., LL.D., etc. Cr. 8vo, pp. xii.—227. (Boston, U.S.A. : Silver, Burdett, and Co. 1897.)

The author thinks that the most excellent manuals of Political Economy now in use involve two serious faults : one, that they generally say too much ; the other, that they do not mark for the eye, in difference of type, any distinction between substantive and subsidiary material. He believes that the best printed presentation of a subject for class-room purposes is the briefest which clearness will allow, leaving indispensable amplifications and illustrations to notes, and that is the method he adopts in the book before us.

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Part 33. JANUARY, 1897. Price 2/6.

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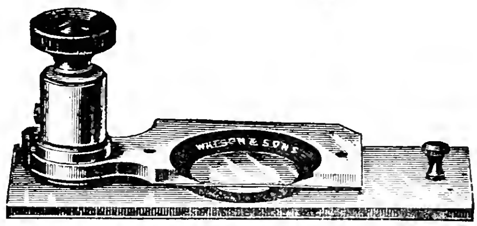

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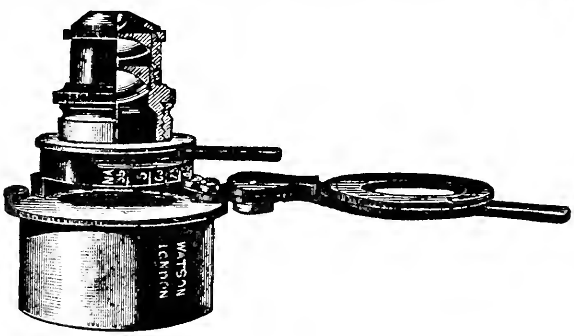

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